ESTATE OF E. L. COOLEY

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A HAND-BOOK

OF

WIRING TABLES

ERRATUM.

Definition of Milli-Ampere on page 45, should read ONE THOUSANDTH instead of one millionth ampere.

NEW YORK CITY:
D. VAN NOSTRAND COMPANY,
23 MURRAY & 27 WARREN STS.,
1892.

A HAND-BOOK

OF

WIRING TABLES

FOR

ARC, INCANDESCENT LIGHTING,
AND MOTOR CIRCUITS.

BY

A. E. WATSON.

NEW YORK CITY:
D. VAN NOSTRAND COMPANY,
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PREFACE.

Electric wiring is not generally well understood. To the average electrician there is a certain amount of mystery connected with the art; yet it is only a matter of simple arithmetic, which any person with ordinary perseverance, can easily master. It is the object of the following pages to furnish the student with such rules and suggestions, as to enable him to solve this problem himself. There is a call for a treatise of this character, to which the present effort is a response. A unique feature of this work is newly compiled tables of the arc and motor wiring systems, brought down to date.

A. E. WATSON.

LYNN, MASS., April 10, 1892.

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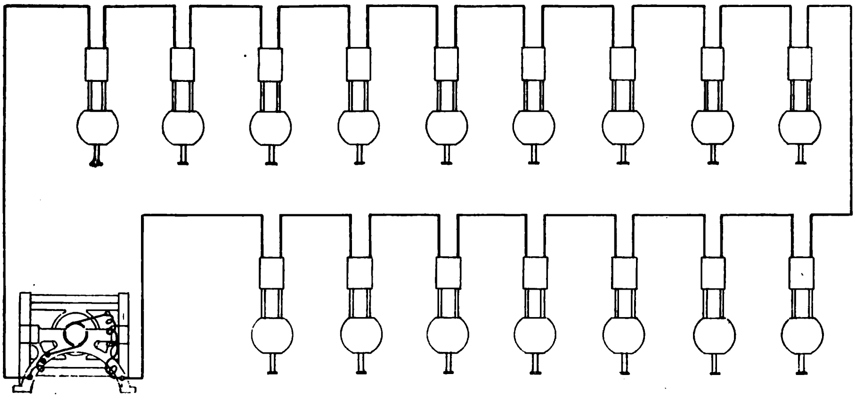
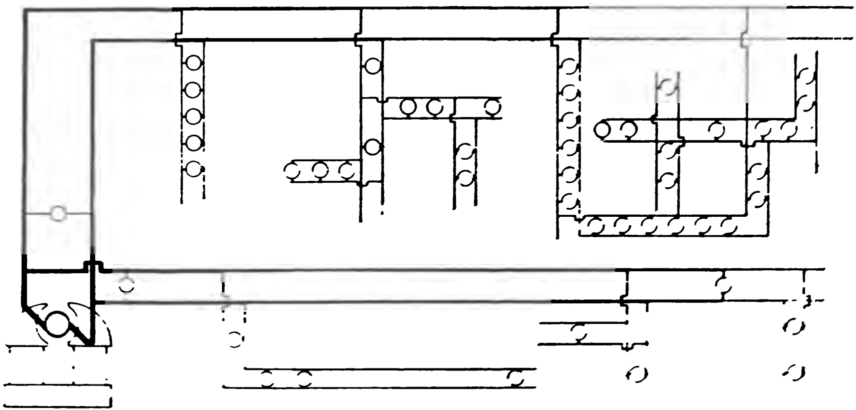
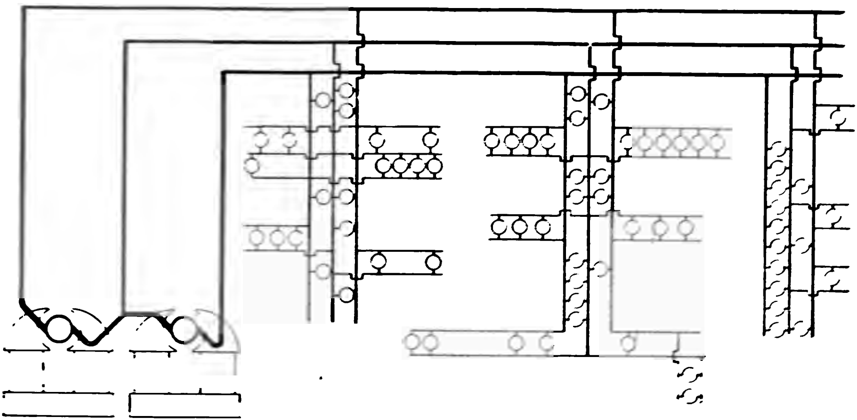


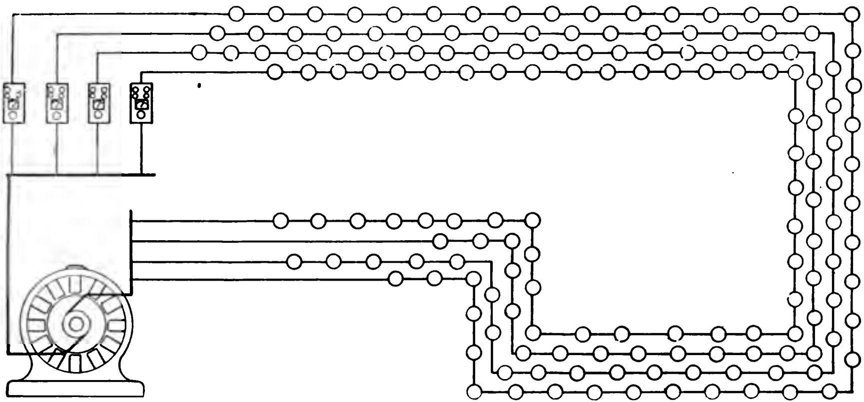
Ordinary Arc Dynamo Circuit with lamps in series.



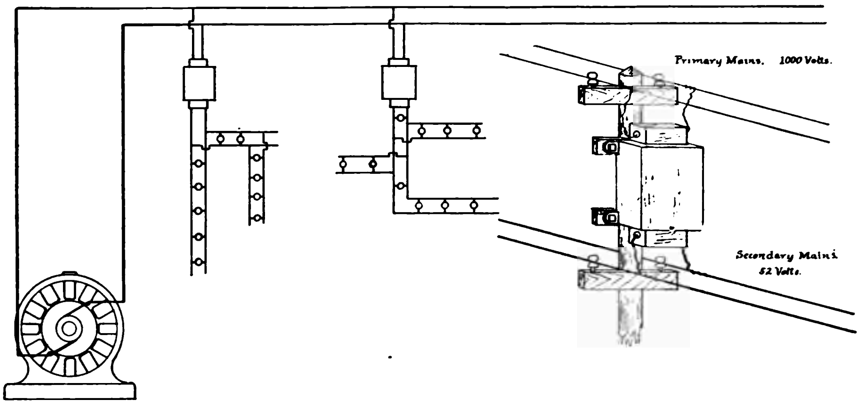
Ordinary 2-Wire Multiple Incandescent System



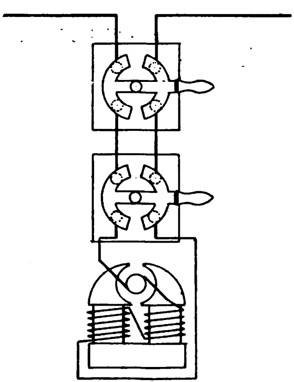
Ordinary 3-Wire Multiple Incandescent System.



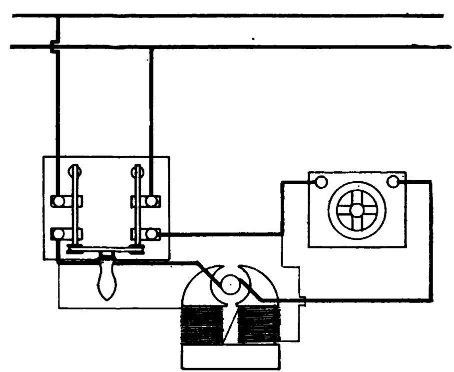
Series Street System using alternating current without transformer.
40—25-volt lamps in series.



Transformer Alternating System; also showing location of transformer on pole.



Series Motor on Arc Circuit, showing also inside and outside Cut-out Switches.



Shunt Motor on Incandescent Circuit, showing also Main Switch and Rheostat.

GENERAL INFORMATION.

THERE are no conductors of electricity that do not offer resistance to the passage of the current. Copper and silver offer the least resistance, yet they have to be subject to careful calculation that there may be no undue waste of energy or material. Such massive bars of copper might be used that the loss in conveying the current through them would be inappreciable, but the interest on the money invested in such amounts of metal would be prohibitive.

The flow of currents of electricity is due to the impressed electro-motive force, and any losses due to the resistance of the wires are expressed in units of this driving power: *i e.*, "volts." The amount of current flowing in a given conductor is the result of this original electro-motive force divided by the resistance of the wire. Ohms' formula is the foundation of all calculations of this nature. If C represents the current in "amperes," E the elec-

tro-motive force in "volts" and *R* the resistance in "ohms" then $C = \frac{E}{R}$.

But the number of volts to overcome the resistance of the circuit must be small as compared with the electro-motive force used for doing commercial work. Depending on the cost of coal and copper, it is common to allow 5 per cent, 10 per cent, or 15 per cent loss. In no case is the safe carrying capacity (without heating) of the wire used as a measure of the amount of current to be carried. This carrying capacity of a wire is far in excess of the amount that it would be commercially profitable to allow, for the loss of energy to force such amounts of current as a wire might carry would be at least 75 per cent of the whole voltage of the dynamo.

Arc and incandescent lighting and motors require different systems of wiring, and under each head peculiarities will be described and illustrations of calculating given.

ARC-LIGHTING.

Arc lamps are run in series; that is, the same current that lights one lamp lights the next one, and so on through the entire circuit operated by one dynamo. As the vol-

tage must overcome the sum of the resistance of all the lamps, it is impracticable and unsafe to supply more than 50 lamps from one machine. It is therefore usual to have as many different circuits as there are dynamos.

Arc lamps are commonly rated as "full arcs" or "half arcs," estimated roughly by the amount of current they use or by the light they furnish. The former use 9.6 amperes and furnish 2000 candle-power lamps, the later 6.8 amperes and 1200 candle-power.

Let it be required to determine the size of wire necessary to use on a circuit of 50 full arc lamps, with a loss of but 10 per cent, allowing 45 volts for each lamp. Fifty lamps would require 2250 volts. But only 90 per cent is to be available for lighting purposes, so $\frac{2250}{90}$ volts = 2500 volts,—the amount the dynamo must supply: 2500—2250 = 250 the number of volts to be lost in overcoming line resistance.

$C=\frac{E}{R}$ since $C=9.6$ and $E=250$ and $R=\frac{E}{C}=\frac{250}{9.6}=26+$ ohms. 8 miles equals 42,240 feet, hence the resistance of 1000 feet would be $\frac{26}{42240}=.6155$ ohms.

Looking at the table on pages 40 and 41 in the column of resistances per 1000 feet, .62849

is the nearest to this number. The size of wire corresponding in the first column is seen to be No. 8 (.128 inches diameter).

It is usual to allow No. 6 wire for such arc circuits, thus bringing the loss as low as 5 per cent, while No. 8 is well adapted to half arc circuits. Arc wiring is the simplest to calculate; indeed, often there is no calculation done at all, as one set of figures answers for the entire circuit, but in

INCANDESCENT LIGHTING

a series of similar figuring must be done as the current passes successively through "bus" bars, mains, feeders, service wires, branches, and individual lamps. An incandescent lamp system is spoken of as having a uniform pressure (in volts) everywhere. This is only approximate, however, and depends upon the amount of current flowing in any particular wire and its distance from the dynamos.

It is common to arrange this system after the style of a gas or water plant, with a center of distribution, from which the main supply wires emerge in all directions. Extras or feeder wires are usually necessary.

Supply wires tapped to the mains enter every house or block to be lighted. Finally these individual wires supply each lamp or group of lamps. The wires are always in duplicate, one to bring the current to the lamp, the other to carry it away. Each lamp in circuit exists independent of all the others, can trace its path back to the dynamo without touching another lamp. In order that all lamps may burn at a uniform brilliancy the sizes of wire should be calculated separately for each installation.

The calculation will depend primarily on the kind of apparatus to be employed, whether direct current, the ordinary two-wire system, the three-wire system, or the alternating system with transformers. Secondarily it will depend on the particular make and candle-power of the lamps. Incandescent lamps have been run on arc circuits, but their use is dangerous, and is discouraged by insurance companies.

Let it be required to determine the size of wires to use in an installation of 100 lamps drawing their current from a center of distribution of a capacity of 1000 lamps one-half mile from the station. The distance of the

house in question, from this center is 120 feet. The lamps are to be located on four floors, 25 lamps on each. The center of the room to which the current is brought is 50 feet from the main junction boxes for each floor. Each lamp is wired separately to the supply wires, there being no groups or chandeliers. The lamps are 110 volt .6 ampere each, and it is decided to allow different percentages of loss for each of these three stages into which the wiring will be divided.

The twelve or thirteen lamps on each side of the junction point to the supply wires can get their current from one size of wire large enough to carry the entire current to the furthest lamp with the $\frac{3}{4}$ per cent loss. This will be $12 \times .6 = 7.2$ amperes, and the distance 15 feet; $\frac{3}{4}$ per cent loss will $99\frac{1}{4}$ available $110 \div 99\frac{1}{4} = 110.8+$, $110.8 - 110 = .8$ volts lost. $R = \frac{E}{C} = \frac{.8}{7.2} = 0.111$ ohms for 30 feet—, twice the fifteen feet to allow for the return. Hence for 1000 feet (in order to be found in the table of resistances) it would be 3.7 ohms. The nearest to this in the table is 3.1 and the size corresponding is No. 15 (.057).

To determine the size of the 50-foot lengths that connect with the main supply wires, and

have a capacity for 25 lamps: Let the loss again be $\frac{3}{4}$ per eent. The current will be $25 \times .6 = 15.0$ amperes. 110.8 (from above) $\div 99\frac{1}{4} = 111.74$ volts. $111.74 - 110.8 = .94$ volts. $R = \frac{e}{c} = \frac{.94}{15} = .06266$ ohms. For 1000 feet it would be .6266 and the size corresponding is No. 8 (128 inches).

The size of the 150 foot lengths from the house to the center of distribution will of course be still larger. Allow 1 per cent, then the 99 per cent available will enter the calculation, $100 \times .6 = 60$ amperes to be carried in all (2×150) 300 feet. 111.74, (from the previous paragraph) $\div .99 = 112.88$. $112.88 - 111.74 = 1.14$ volts lost. $R = \frac{e}{c} = \frac{1.14}{60} = .019$ for 300 feet. For 1000 feet it would be .0633; the size nearest is No. 000 (.409 inches).

From the center of distribution to the station where the dynamos are located was called one-half mile, the length of the circuit will be one mile, or 5280 feet. It is usual to allow more loss in this length than has entered the preceding calculations. Let it be 8 per cent, leaving 92 per cent as effective for lighting. $112.88 \div 92 = 122.70$. $122.70 - 112.88 = 9.82$ volts lost in this part of the system, for conveying current for 1000 lamps as

stated. $1000 \times .6 = 600$ amperes. $R = \frac{E}{C} = \frac{9.82}{600} =$ .01636 ohms resistance for 5280 feet; for 1000 feet it would be .0031 which is outside the reach of the table but could be found to be a wire or rod $1\frac{7}{8}$ inches diameter. In practice, this size would be secured by running several smaller wires in multiple.

It is inconvenient for the wire man to figure out these dimensions for every installation, so electric manufacturing companies usually publish tabulated lists from which it is possible to determine the proper sizes of wires to be used. Different sizes and makes of lamps and different working voltages make variations of more or less importance between the Edison, Thomson-Houston, and Westinghouse systems. Besides, all companies do not use the same standard for wire gauges.

THREE–WIRE SYSTEM.

The economy of this arrangement of wires cannot be definitely stated. It depends on the "balance" or lack of balance between the number of lamps on both sides of the "neutral" wire. At the best there is a saving of one wire, and the use of lamps of practically

twice the ordinary potential. The figuring will be the same as for two ordinary two-wire systems, but with one wire in common.

The principle of this system has been extended to four-wire and five-wire arrangements, but the practical adoption of such was rendered unnecessary by the advent of the more flexible

ALTERNATING SYSTEM.

The advantage of this system lies in the small line wires it is possible to employ, the proper pressure for the lamps being attained by transformers or converters. Lamps of comparatively low voltage can be successfully used.

Two calculations, alike in nature to the previous cases for incandescent lamps are necessary for this system, one for the primary mains, one for the house mains. The tables for the direct current, two-wire system, cannot be made to apply to the secondary, or house mains, with the alternating current as the former are figured for 110 volt-lamps, the latter for 50 or 52 volts.

MUNICIPAL SYSTEM.

This is a modification of the ordinary arrangement of lamps, and can be worked by either a continuous or alternating current. The lamps are put in series of 40 on one circuit. The current in each circuit is kept constant, usually at 3½ amperes, so the figuring is the same as for an arc system.

MOTOR SYSTEMS.

Series motors on arc circuits are to be wired with the same size as the rest of the line wire. As the current is constant, being controlled by the regulator on the generating dynamo, no rheostat is necessary. In figuring the resistance of the line, it is well to assume each horse-power of the motor equivalent to an arc lamp.

Series motors for elevators and some other intermittent machinery are usually supplied from constant potential mains, and in such cases need a rheostat in the circuit to be used in starting only.

In constant potential mains when shunt motors are used a rheostat must always be used in starting. The wiring can be figured on the same basis as if a bank of incan-

descent lamps were in place of the motor. Leaving out of consideration the size of wires in the street mains, which can be figured in the same way, let it be required to figure for a motor of five horse-power to maintain 110 volts at the brushes; the motor to be located one-fourth mile from the mains and a loss of 5 per cent permitted. The current to be accommodated will be about 40 amperes.

$\frac{110}{.95}=116$ volts. $116-110=6$ volts loss.

$R=\frac{E}{C}=\frac{6}{40}=.15$ ohms for $\frac{1}{2}$ mile of wire or 2640 feet. $\frac{.15}{2.640}=.0567$ ohms per 1000 feet, which is about 000 wire (.409).

GENERAL FORMULAE FOR ALTERNATING CIRCUIT WIRING.

A = Area required in circular mills.
D = Single distance.
N = Number lamps of any voltage.
C = Current in amperes per lamp.
E = Number volts per lamp lost in line.
R = Ratio of conversion.

PRIMARY CIRCUITS.

$$A=\frac{21 \times D \times N \times C}{E R^2}$$

For example: Let it be required to determine

the size of wire to carry 400 16 candle-power 52 volt lamps, each using 1.06 amperes, a distance of 2500 feet, on a loss of 5 per cent, with an initial electro-motive force of 1040 volts. A loss of 5 per cent on a 52-volt lamp is 2.6 volts, and the ratio of conversion is $\frac{1040}{52}=20$, whence

$$A=\frac{21 \times 2500 \times 400 \times 1.06}{2.6 \times (20 \times 20)}=21404=\text{No. 7 wire.}$$

SECONDARY CIRCUITS.

The formula for this is $A=\frac{21 \times D \times N \times C}{E}$

For example: A house is to be connected with secondary mains 110 feet distant, and have current for 23, 52 volt 16 candle-power lamps. Each lamp requires 1.06 amperes, and a loss of 2 per cent is permitted.

Then $A=\frac{21 \times 110 \times 23 \times 1.06}{1.04}=54151=\text{No. 3 wire.}$

To accommodate different percentages of loss for both primary and secondary mains the following tables have been inserted. The numbers opposite the figures, indicating the different percentages, are constants which are to be multiplied by the number of lamps, and by the distance (in feet) to get the circular mills of the wire necessary to use.

CONSTANTS FOR

Primary Mains. Secondary Mains.

Per cent loss.	104 volt lamps. 1040 volts.	104 volt lamps. 2080 volts.	52 volt lamps. 1040 volts.	52 volt lamps. 2080 volts.	Per cent loss.	52 volt lamps.	75 volt lamps.	104 volt lamps.
1	0.121	.030	.101	.025	1	40.5	21.4	12.1
2	.060	.015	.050	.0125	2	20.2	10.7	6.0
3	.040	.010	.033	.008	3	13.5	7.1	4.0
4	.030	.075	.025	.006	4	10.1	5.3	3.0
5	.024	.060	.020	.005	5	8.1	4.3	2.4
6	.020	.050	.017	.004	6	6.8	3.6	2.0
8	.015	.038	.013	.003	8	5.0	2.7	1.5
10	.012	.030	.010	.0025	10	4.0	2.1	1.2
12	.010	.025	.008	.002	12	3.4	1.8	1.0
15	.008	.020	.007	.0017	15	2.7	1.4	.8
20	.006	.015	.005	.0012	18	2.3	1.1	.7
25	.005	.012	.004	.001	20	2.0	1.0	.6

EXAMPLES OF PRECEDING TABLE OF CONSTANTS.

PRIMARY MAINS.

1. Required size of line wire for 450 52-volt 16 c. p. lamps, 1200 feet from dynamo; 5 per cent allowed for loss, on 2080 volts at brushes of dynamo.

$450 \times 1200 \times .005 = 2700$ circular mills = No. 16 wire.

(While this size would fill the theoretical requirements, it would be inadvisable to employ such a small size, as the tensile strength would be insufficient to resist the mechanical strains that pole lines are subject to.)

2. Required size of line wire for 1300 52-volt, 16 c. p. lamps, 3 miles (15840 feet) from station, with 12 per cent loss.

$1300 \times 15840 \times .008 = 164736$ cir. mills = 000 wire.

3. Required size of wire for 280 104-volt lamps, 3400 feet distance, 1040 volts; 8 per cent loss.

$280 \times 3400 \times .15 = 142800$ cir. mills = 00 wire.

SECONDARY AND HOUSE MAINS.

1. Required size of wire for 36 52-volt lamps, 106 feet from transformers, 3 per cent loss.
$36 \times 106 \times 13.5 = 51516$ cir. mills = No. 3 wire.

2. Required size of wire for 2 104-volt lamps, 60 feet from transformer, 1 per cent loss.

$2 \times 60 \times 12.1 = 14520$ cir. mills = No. 9 wire.

3. A cluster of 16 52-volt lamps is 148 feet from transformer; allowing 2 per cent loss, what size of wires to use.

$16 \times 148 \times 20.2 = 47833$ cir. mills = No. 3 wire.

EDISON SYSTEM.

BIRMINGHAM GAUGE.

Gauge Number:	Diameter, in mils,	Sectional area in circular mils.=D²	Maximum safe current in Amperes.	Pounds per Foot.	Ohms per Foot.
0000	454	206116	306	.6239	.00005008
000	425	180625	278	.5468	.00005715
00	380	144400	234	.4371	.00007149
0	34	115600	199	.3499	.0000893
1	300	90000	164	.2724	.0001147
2	284	80656	151	.2442	.0001280
3	259	67081	132	.2030	.0001540
4	238	56644	116	.1715	.0001827
5	22	48400	103	.1465	.0002128
6	203	41209	92	.1247	.0002507
7	18	32400	76	.09808	.0003186
8	165	27225	67	.08241	.0003792
9	148	21904	57	.06631	.0004711
10	134	17956	49	.05435	.0005749
11	12	14400	42	.04359	.0007169
12	109	11881	36	.03596	.0008689
13	95	9025	29	.02732	.001144
14	83	6889	24	.02085	.001499
15	72	5184	19	.01569	.001991
16	65	4225	17	.01279	.002443
17	58	3364	14	.01018	.003069
18	49	2401	11	.007268	.004300
1-2 in.	...	250000	354	.7568	.00004129
9-16 "	...	316969	422	.9595	.00003227
5-8 "	...	390625	494	1.1824	.00002643

General Formula for Wiring.

$$K=\frac{21.68 \times (100-\text{per cent. loss in Lamps.})}{(\text{Resistance of one Lamp}) \times (\text{per cent. loss in wire.})}$$

Circular mils.=K x (mean distance) x (No. of Lamps.)

EDISON SYSTEM.

EDISON GAUGE.

E. S. G. Gauge No.	Diameter in mils.	Circular Mils, in Even Thous.	Maximum Amperes.	Ohms per Foot.	Pounds per Foot.
3	55	3000.	12.5	.0034976	00908372
5	71	5000.	18.3	.0020986	01513924
8	90	8000.	26.0	.0013118	02422034
12	110	12000.	35.2	.0008746	03632824
15	123	15000.	41.6	.0006997	04540984
20	142	20000.	51.6	.0005247	06054840
25	158	25000.	61.0	.0004198	07568210
30	173	30000.	70.0	.0003498	09081666
35	187	35000.	78.6	.0002999	.10595483
40	200	40000.	86.8	.0002624	.12108200
45	212	45000.	94.9	.0002332	.13622748
50	224	50000.	102.7	.0002099	.15135683
55	235	55000.	110.3	.0001908	.16650083
60	245	60000.	117.7	.0001749	.18162452
65	255	65000.	125.0	.0001615	.19677218
70	265	70000.	132.1	.0001499	.21190130
75	274	75000.	139.1	.0001399	.22704321
80	283	80000.	146.0	.0001312	.24217648
85	292	85000.	152.8	.0001235	.25730349
90	300	99000.	159.5	.0001166	.27243450
95	308	95000.	166.1	.0001105	.28758723
100	316	100000.	172.6	.0001049	.30270928
110	332	110000.	185.4	.0000954	.33299060
120	346	120000.	198.0	.0000845	.36326663
130	361	130000.	210.2	.0000807	.39352714
140	374	140000.	222.2	.0000750	.42379665
150	387	150000.	234.0	.0000700	.45406140
160	400	160000.	245.6	.0000656	.48432800
170	412	170000.	257.0	.0000617	.51462206
180	424	180000.	268.3	.0000583	.54488123
190	436	190000.	279.4	.0000552	.57513978
200	447	200000.	290.4	.0000525	.60542734

Formula for Calculating Wire for New Style Lamps.

$$\text{Cir. mils.} = \frac{(\text{No. of lamps}) \times (\text{mean distance}) \times 10.}{(\text{per cent. loss.})}$$

Divide by 4 for 3 wire system.

EDISON SYSTEM.

TABLE OF CONSTANTS FOR CALCULATING WIRE. Constants for one 16 c. p. Lamp (3.1 Watts.

Distance in Feet.	PER CENT. LOSS IN WIRE.											
	½	1	2	3	4	5	6	8	10	12	15	20
25	500	250	.....	.....	....	....	....	...	....	....	....	....
50	1000	500	250	.....	....	....	....	....	....	....	...	....
75	1500	750	375	250	188	....	....	....	....	....	....	....
100	2000	1000	500	333	250	200	....	....	....	....	....	....
125	2500	1250	625	417	313	250	208	....	....	....	....	....
150	3000	1500	750	500	375	300	250	188	....	...	....	....
200	4000	2000	1000	667	500	400	330	250	200	....	..	....
300	6000	3000	1500	1000	750	600	500	375	300	250	200	....
400	8000	4000	2000	1333	1000	800	667	500	400	333	267	200
500	10000	5000	2500	1667	1250	1000	833	625	500	417	333	250
600	12000	6000	3000	2000	1500	1200	1000	750	600	500	400	300
800	16000	8000	4000	2667	2000	1600	1333	1000	800	667	533	400
1000	20000	10000	5000	3333	2500	2000	1667	1250	1000	833	667	500
1200	24000	12000	6000	4000	3000	2400	2000	1500	1200	1000	800	600
1500	30000	15000	7500	5600	3750	3000	2500	1875	1500	1250	1000	750
1800	36000	18000	9000	6000	4500	3600	3000	2250	1800	1500	1200	900
2000	40000	20000	10000	6667	5000	4000	3300	2500	2000	1667	1333	1000

Cir. Mils.=Number of Lamps x by above Constant.
Divide by 4 for 3-wire System.
Check Size Wire for Ampere Capacity in using Table.

TABLE OF WIRE "B. AND S." GAUGE.

GAUGE.	Diam. in $\frac{1}{1000}$ inch.	Area in Circ. Mills. $A=D^2$	Lbs. per ft. bare.	Lbs. per ft. covered.	Resist'n'c in ohms. per foot.	Cents per Foot Covered, At 16c. lb.	At 18c. lb.	At 20c. lb.
0000	.460	211600	.639	.821	.0000491	.1314	.1478	.1642
000	.410	167805	.507	.619	.0000619	.099	.1114	.1238
00	.365	133079	.402	.441	.000078	.0706	.0794	.0882
0	.325	105592	.319	.356	.0000983	.057	.0641	.0712
1	.289	83694	.253	.284	.000124	.0454	.0511	.0568
2	.258	66373	.201	.235	.0001564	.0376	.0423	.0470
3	.229	52634	.159	.191	.0001974	.0306	.0344	.0382
4	.204	41742	.126	.158	.0002487	.0253	.0284	.0316
5	.182	33102	.1	.127	.0003136	.0203	.0229	.0254
6	.162	26250	.079	.102	.0003955	.0163	.0184	.0204
7	.144	20816	.063	.085	.0004987	.0136	.0153	.017
8	.128	16509	.05	.069	.0006288	.011	.0124	.0138
9	.114	13094	.04	.054	.0007928	.0086	.0097	.0108
10	.102	10381	.031	.047	.001	.0075	.0085	.0094
11	.091	8234	.025	.036	.0012607	.0058	.0065	.0072
12	.081	6530	.02	.031	.0015898	.005	.0056	.0062
13	.072	5178	.016	.026	.0020047	.0042	.0047	.0052
14	.064	4107	.012	.02	.0025908	.0032	.0036	.004

THE WESTING

WIRING TABLE FOR 50 VOLT LAMPS.

Amperes or 16 C.P. Lamps.	Distance in Feet to Center of Distribution.							
	20'.	25'.	30'.	35'.	40'.	45'.	50'.	60'.
1.	16.	16.	16.	16.	16.	16.	16.	16.
1.5	16.	16.	16.	16.	16.	16.	16.	16.
2.	16.	16.	16.	16.	16.	16.	16.	16.
3.	16.	16.	16.	16.	16.	15.	15.	14.
4.	16.	16.	16.	15.	15.	14.	13.	13.
5.	16.	16.	15.	14.	13.	13.	13.	12.
6.	16.	15.	14.	13.	13.	12.	12.	11.
7.	15.	14.	13.	13	12.	12.	11.	11.
8.	15.	14.	13.	12.	12.	11.	11.	10.
9.	14.	13.	12.	12.	11.	11.	10.	9.
10.	14.	13.	12.	11.	11.	10.	10.	9.
12.	13.	12.	11.	11.	10.	10.	9.	8.
14.	12.	11.	10.	10.	9.	9.	8.	7.
16.	12.	11.	10.	9.	9.	8.	8.	7.
18.	11.	10.	9.	8.	8.	7.	7.	6
20.	11.	10.	9.	8.	8.	7.	7.	6.
25.	10.	9.	8.	7.	7.	6.	6.	5.
30.	9.	8.	7.	7.	6.	5.	5.	4.
35.	8.	7.	7.	6.	5.	5.	4.	4.
40.	8.	7.	6.	5.	5.	4.	4.	3.
45.	7.	6.	5.	5.	4.	4.	3.	2.
50.	6.	6.	5.	4.	4.	3.	3.	2.
55.	6.	5.	5.	4.	3.	3.	2.	2.
60.	5.	5.	4.	4.	3.	3.	2.	1.
65.	5.	5.	4.	3.	3.	2.	2.	1.
70.	4.	4.	4.	3.	2.	2.	1.	1.
75.	4.	4.	3.	3.	2.	1.	1.	0.
80.	3.	3.	3.	2.	2.	1.	1.	0.
90.	3.	3.	2.	2.	1.	1	0.	00.
100.	2.	2.	2.	1.	1.	0.	0.	00

HOUSE SYSTEM.

LOSS 1 VOLT=2 PER CENT.

Wire Sizes are Indicated Below in B. & S. Gauge.								
70.	80.	90.	100.	120.	140.	160.	180.	200.
16.	16.	16.	16.	16.	15	14.	14.	13.
15.	15.	15.	14.	14.	13.	13.	12.	11.
15	15.	14.	13.	13.	12.	12.	11.	10.
13.	13	12.	12.	11.	10.	10.	9.	9.
12	11	11.	10	10.	9.	8.	8.	7.
11.	11	10	10.	9.	8.	8.	7.	7
11.	10.	10.	9.	8	8.	7.	7.	6.
10.	9	9.	8.	8.	7.	6.	6.	5.
9.	9.	8.	8	7.	6.	6	5.	5.
9.	8.	8.	7.	6.	6.	5.	5.	4.
8.	8	7.	7.	6.	5.	5.	4.	4.
8.	7.	7.	6.	5.	5.	4.	4.	3.
7.	6.	6.	5.	4.	4.	3.	3.	2.
6.	6.	5.	5.	4.	3.	3.	2.	2.
6.	5.	5.	4.	3..	3.	2.	2.	1.
5..	5.	4.	4	3.	2.	2.	1.	1
4.	4.	3.	3.	2.	1.	1.	0.	0.
3.	3.	2.	2.	1.	0.	0.	0.	00.
3.	2.	2.	1.	1.	0.	00.	00.	000.
2.	2.	1.	1.	0.	00.	000.	000.	000.
2.	1.	1.	0.	00.	00.	000.	000.	0000.
1.	1.	0.	0.	00.	000.	000.	0000.	0000.
1.	0.	0.	00.	00.	000.	0000.	0000.	0000.
0.	0.	00.	00.	000.	000.	0000.	0000.	
0.	0.	00.	00.	000.	0000.	0000	ST'D. LAMPS	
0.	00.	00.	000.	000.	0000.	0000.	10.cp.	0.7 a.
00.	00	000.	000.	0000.	0000.		16. "	1. "
00.	00.	000.	000.	0000.	0000.		25. "	1.5 "
00.	000.	000.	0000.	0000.			50. "	3. "
000.	000.	0000.	0000.				150. "	9. "

THE THOMSON

WIRING TABLE. 16-CANDLE

52 Volt Lamps.	75 Volt Lamps.	110 Volt Lamps.	220 Volt Lamps.	330 Volt Lamps.	Distance in feet to center of Distribution.						
					20'.	25'.	30'.	40'.	50'.	60'.	70'.
1	1.3	1 5	3.	5.	16.	16.	16	16.	16.	16.	16
1 5	2.	2.5	5.	7.	16.	16	16.	16.	16.	16.	15.
2	2.6	3.	6	10.	16.	16.	16.	16.	16.	16.	15.
3.	4	5.	10.	15.	16.	16.	16.	16.	15.	14.	13
4	5.	7.	13.	20.	16.	16.	16.	15.	13.	13.	12.
5	6.	8.	16.	25.	16	16..	15	13.	13.	12.	11
6	8.	10.	20.	30.	16.	15.	14.	13.	12.	11.	11
7.	9.	11	23.	35.	15.	14.	13.	12.	11.	11.	10
8.	10	13.	26.	40.	15.	14.	13.	12.	11.	10.	9
9.	12.	15	30.	45.	14.	13.	12.	11.	10.	9.	9
10.	13.	16.	33.	50.	14.	13.	12.	11.	10.	9.	8.
12.	16.	20.	40.	60.	13.	12.	11.	10.	9.	8.	8
14.	18.	23.	46	70.	12.	11.	10.	9.	8.	7	7
16.	20.	28.	53.	80.	12.	11.	10.	9.	8.	7.	6.
18	23.	30	60.	90.	11.	10.	9.	8.	7	6.	6.
20.	27	83.	66.	100.	11.	10.	9.	8.	7.	6.	5
25..	33.	41.	83.	125.	10.	9.	8.	7	6.	5.	4
30	40.	50.	100.	150.	9.	8.	7.	6.	5.	4.	3.
35.	46.	58.	116.	175.	8.	7.	7.	5.	4.	4.	3.
40.	52	66.	133.	200.	8.	7.	6.	5.	4	3.	2.
45.	59	75.	150	225.	7.	6.	5.	4.	3.	2.	2.
50.	65.	83.	166.	250	6.	6.	5.	4.	3.	2.	1.
55.	72.	91.	183.	275.	6.	5.	5.	3	2.	2.	1.
60.	79	100.	200.	300.	5.	5.	4.	3.	2.	1.	0.
65.	85.	108.	216.	325.	5.	5.	4.	3.	2.	1	0
70	92.	116.	233.	350.	4.	4.	4.	2.	1.	1.	0.
75	98.	125.	250.	375.	4.	4.	3.	2	1.	0.	00
80.	105.	133.	266.	400.	3.	3.	3.	2.	1.	0.	00.
90.	118.	150.	300.	450.	3.	3.	2.	1.	0.	00.	00.
100	131.	166.	333.	500.	2.	2.	2	1.	0.	00.	000.

HOUSTON SYSTEM.

POWER LAMPS **LOSS 1 VOLT**

Wire sizes are indicated below in B. & S. gauge.								Gauge Number.	Carrying Capac'y in Amperes.
80'.	90'.	100'.	120'.	140'.	160'.	180'.	200'.		
16.	16.	16.	16.	15.	14.	14.	13.	16.	3.9
15.	15.	14.	14.	13.	13.	12.	11.	15.	4.9
15.	14.	13.	13.	12.	12.	11.	10.	14.	6.2
13.	12.	12.	11.	10.	10.	9.	9.	13.	7.9
11.	11.	10.	10.	9.	8.	8.	7.	12.	9.9
11.	10.	10.	9.	8.	8.	7.	7.	11.	12.5
10.	10.	9.	8.	8.	7.	7.	6.	10.	15
9.	9.	8.	8.	7.	6.	6.	5.	9.	20
9.	8.	8.	7.	6.	6.	5.	5.	8.	25
8.	8.	7.	6.	6.	5.	5.	4.	7.	32
8.	7.	7.	6.	5.	5.	4.	4.	6.	40.
7.	7.	6.	5.	5.	4.	4.	3.	5.	50
6.	6.	5.	4.	4.	3.	3.	2.	4.	63.
6.	5.	5.	4.	3.	3.	2.	2.	3.	80.
5.	5.	4.	3.	3.	2.	2.	1.	2.	101
5.	4.	4.	3.	2.	2.	1.	1.	1.	127.
4.	3.	3.	2.	1.	1.	0.	0.	0.	161.
3.	2.	2.	1.	0.	0.	0.	00.	00.	202.
2.	2.	1.	1.	0.	00.	00.	000.	000	255.
2.	1.	1.	0.	00.	000.	000.	000.	0000.	322
1.	1.	0.	00.	00.	000.	000.	0000.		
1.	0.	0.	00.	000.	000.	0000.	0000.		
0.	0.	00.	00.	000.	0000.	0000.	0000.		
0.	00.	00.	000.	000.	0000.	0000.			
0.	00.	00.	000.	0000.	0000.				
00.	00.	000.	000.	0000.	0000.				
00.	000.	000.	0000.	0000.					
00.	000.	000.	0000.	0000.					
000.	000.	0000.	0000.						
000.	0000.	0000.							

Table of Different Gauges, with their Diameters and Areas in Mils.

STANDARD.			AMERICAN.			BIRMINGHAM.		
No of Gauge.	Diameter in Mils.	Area in C M=d²	No. of Gauge.	Diameter in Mils.	Area in C M=d²	No. of Gauge.	Diameter in Mils	Area in C M=d²
7-0	500	250000						
6-0	464	215296	4-0	4600	211600	4-0	454	206116
5-0	432	186624				3-0	425	180625
4-0	400	160000	3-0	4096	167805			
3-0	372	138384	2-0	3648	133079	2-0	380	144400
2-0	348	121104				0	340	115600
0	324	104976	0	3249	105592			
1	300	90000				1	300	90000
2	276	76176	1	2893	83694	2	284	80656
3	252	63504	2	2576	66373	3	259	67081
4	232	53824	3	2294	52634	4	238	56644
5	212	44944				5	220	48400
6	192	36864	4	2043	41742	6	203	41209
7	176	30976	5	1819	33.02	7	180	32400
8	160	25600	6	162	26244	8	165	27225
9	144	20736	7	1443	20822	9	148	21904
10	128	16384	8	1285	16512	10	134	17956

Table of Different Gauges, with their Diameters and Areas in Mils.

STANDARD.			AMERICAN.			BIRMINGHAM.		
No. of Gauge.	Diameter in Mils.	Area in C M=d²	No. of Gauge.	Diameter in Mils.	Area in C M=d²	No. of Gauge.	Diameter in Mils.	Area in C M=d²
11	116	13456	9	1144	13110	11	120	14400
12	104	10816	10	1019	10381	12	109	11881
13	092	8464	11	0907	8226	13	095	9025
14	080	6400	12	0808	6528	14	083	6889
15	072	5184	13	072	5184	15	072	5184
16	064	4096	14	0641	4110	16	065	4225
17	056	3136	15	0571	3260	17	058	3364
18	048	2304	16	0508	2581	18	049	2401
			17	0452	2044	19	042	1764
19	040	1600	18	0403	1624			
20	036	1296	19	0359	1253	20	035	1225
21	032	1024	20	032	1024	21	032	1024
22	028	784	21	0285	810	22	028	784
23	024	576	22	0253	626	23	025	625
24	022	484	23	0226	510	24	022	484
25	020	400	24	0201	404	25	020	400
26	018	324	25	0179	320	26	018	324

TABLE SHOWING THE DIFFERENCE BETWEEN WIRE GAUGES.

No.	New British.	London.	Stubs'.	Brown & Sharpe's
0000	.400	.454	.454	.460
000	.372	.425	.425	.40964
00	.348	.380	.380	.36480
0	.324	.340	.340	.32495
1	.300	.300	.300	.28930
2	.276	.284	.284	.25763
3	.252	.259	.259	.22942
4	.232	.238	.238	.20431
5	.212	.220	.220	.18194
6	.193	.203	.203	.16202
7	.176	.180	.180	.14428
8	.160	.165	.165	.12849
9	.144	.148	.148	.11443
10	.128	.134	.134	.10189
11	.116	.120	.120	.09074
12	.104	.109	.109	.08081
13	.092	.095	.095	.07196
14	.080	.083	.083	.06408
15	.072	.072	.072	.05706
16	.064	.065	.065	.05082
17	.056	.058	.058	.04525
18	.048	.049	.049	.04030
19	.040	.040	.042	.03589
20	.036	.035	.035	.03196
21	.032	.0315	.032	.02846
22	.028	.0295	.028	.025347
23	.024	.027	.025	.022571
24	.022	.025	.022	.0201
25	.020	.023	.023	.0179
26	.018	.0105	.018	.01594
27	.0164	.01875	.016	.014195
28	.0148	.0165	.014	.012641
29	.0136	.0155	.013	.011257
30	.0124	.01375	.012	.010025
31	.0116	.01225	.010	.008928
32	.0108	.01125	.009	.00795
33	.0100	.01025	.008	.00708
34	.0092	.0095	.007	.0063
35	.0084	.009	.005	.00561
36	.0075	.0074	.004	.005

TABLE OF ELECTRICAL UNITS.

UNIT OF	NAME		DERIVATION.
Electromotive force.........	Volt........	E	Ampere × Ohm.
Resistance......	Ohm.	R	Volt ÷ Ampere
Current	Ampere	C	Volt ÷ Ohm
Quantity........	Coulomb ...	Q	Ampere × Second
Capacity........	Farad	K	Coulomb ÷ Volt
Power..........	Watt.......	P	Ampere × Volts

CONDUCTORS.

Good Conductors—Silver, copper, gold, and other metals.

Partial Conductors—Human body, water, marble, cotton, wood and paper.

Non-Conductors—Dry air, glass, porcelain, mica, gutta-percha, ebonite, silk and oils.

Table of Dimensions and Resistances of Pure Copper Wire.*

REVISED.

No. B. & S.	Diam. Mils.	Area. Circular Mils.	Area. Square Inches.	W'gt & Length. Sp. gr. 8.9 Lbs. per 1000 ft.	Pounds per mile.	Feet per pound.
0000	460.000	211600.0	166190.2	640.73	3383.04	1.56
000	409.640	167805.0	131793.7	508.12	2682.85	1.97
00	364.800	133079.0	104520.0	402.97	2127.66	2.48
0	324.950	105592.5	82932.2	319.74	1688.20	3.13
1	289.300	83694.5	65733.5	253.43	1338.10	3.95
2	257.630	66373.2	52129.4	200.98	1061.17	4.98
3	229.420	52633.5	41338.3	159.38	841.50	6.28
4	204.310	41742.6	32784.5	126.40	667.38	7.91
5	181.940	33102.2	25998.4	100.23	529.23	9.98
6	162.020	26250.5	20617.1	79.49	419.69	12.58
7	144.280	20816.7	16349.4	63.03	332.82	15.86
8	128.490	16509.7	12966.7	49.99	263.96	20.00
9	114.430	13094.2	10284.2	39.65	209.35	25.22
10	101.890	10381.6	8153.67	31.44	165.98	31.81
11	90.742	8234.11	6467.06	24.93	131.65	40.11
12	80.808	6529.94	5128.60	19.77	104.40	50.58
13	71.961	5178.39	4067.09	15.68	82.792	63.78
14	64.084	4106.76	3225.44	12.44	65.658	80.42
15	57.068	3256.76	2557.85	9.86	52.069	101.40
16	50.820	2582.67	2028.43	7.82	41.292	127.87
17	45.257	2048.20	1608.65	6.20	32.746	161.24
18	40.303	1624.33	1275.75	4.92	25.970	203.31
19	35.890	1288.09	1011.66	3.90	20.594	256.89
20	31.961	1021.44	802.24	3.09	16.331	323.32
21	28.462	810.09	636.24	2.45	12.952	407.67
22	25.347	642.47	504.60	1.95	10.272	514.03
23	22.571	509.45	400.12	1.54	8.1450	648.25
24	20.100	404.01	317.31	1.22	6.4593	817.43
25	17.900	320.41	251.65	.97	5.1227	1030.71
26	15.940	254.08	199.56	.77	4.0623	1299.77
27	14.195	201.50	158.26	.61	3.2215	1638.97
28	12.641	159.80	125.50	.48	2.5548	2066.71
29	11.257	126.72	99.526	.38	2.0260	2606.13
30	10.025	100.50	78.933	.30	1.6068	3286.04
31	8.928	79.71	62.603	.24	1.2744	4143.18
32	7.950	63.20	49.639	.19	1.0105	5225.26
33	7.080	50.13	39.369	.15	.8014	6588.33
34	6.304	39.74	31.212	.12	.6354	8310.17
35	5.614	31.52	24.753	.10	.5039	10478.46
36	5.000	25.00	19.635	.08	.3997	13209.98
37	4.453	19.83	15.574	.06	.3170	16654.70
38	3.965	15.72	12.347	.05	.2513	21006.60
39	3.531	12.47	9.7923	.04	.1993	26427.83
40	3.144	9.88	7.7365	.03	.1580	33410.05

're copper wire 1-16 in. diam.=13.59 ohms at 15.5°C or 59.9°F.

Table of Dimensions and Resistances of Pure Copper Wire.*

REVISED.

No. B. & S.	Resistance at 75°F.				lbs p. 1000 ft. ins'd H.B.&H. line wire.	Feet per lb. ins'd H.B.&H. line wire.
	R ohms per 1000 feet.	Ohms per mile.	Feet per ohm.	Ohms per pound.		
4-0	.04904	.25891	20392.9	.00007653	800	1.25
3-0	.06184	.32649	16172.1	.00012169	666	1.50
00	.07797	.41168	12825.4	.00019438	500	2.00
0	.09827	.51885	10176.4	.00030734	363	2.75
1	.12398	.65460	8066.0	.00048920	313	3.20
2	.15633	.82543	6396.7	.00077784	250	4.00
3	.19714	1.04090	5072.5	.0012370	200	5.00
4	.24858	1.31248	4022.9	.0019666	144	6.9
5	.31346	1.65507	3190.2	.0031273	125	8.0
6	.39528	2.08706	2529.9	.0049728	105	9.5
7	.49845	2.63184	2006.2	.0079078	87	11.5
8	.62849	3.31843	1591.1	.0125719	69	14.5
9	.79242	4.18400	1262.0	.0199853		
10	.99948	5.27726	1000.5	.0317946	50	20.0
11	1.2602	6.65357	793.56	.0505413		
12	1.5890	8.39001	629.32	.0803641	31	32.0
13	2.0037	10.5798	499.06	.127788		
14	2.5266	13.3405	395.79	.203180	22	45.0
15	3.1860	16.8223	313.87	.323079		
16	4.0176	21.2130	248.90	.513737	14	70.0
17	5.0660	26.7485	197.39	.816839		
18	6.3880	33.7285	156.54	1.298764	11	90.0
19	8.0555	42.5329	124.14	2.065312		
20	10.1584	53.6362	98.44	3.284374		
21	12.8088	67.6302	78.07	5.221775		
22	16.1504	85.2743	61.92	8.301819		
23	20.3674	107.540	49.10	13.20312		
24	25.6830	135.606	38.94	20.99405		
25	32.3833	170.984	30.88	33.37780		
26	40.8377	215.623	24.49	53.07946		
27	51.4952	271.895	19.42	84.39916		
28	64.9344	342.854	15.40	134.2005		
29	81.8827	432.341	12.21	213.3973		
30	103.245	545.133	9.686	339.2673		
31	130.176	687.327	7.682	539.3404		
32	164.174	866.837	6.091	857.8498		
33	207.000	1092.96	4.831	1363.786		
34	261.099	1378.60	3.830	2169.776		
35	329.225	1738.31	3.037	3449.770		
36	415.047	2191.45	2.409	5482.766		
37	523.278	2762.91	1.911	8715.030		
38	660.011	3484.86	1.515	13864.51		
39	832.228	4394.16	1.202	22043.92		
40	1049.718	5542.51	.9526	35071.11		

*1 mile pure copper wire 1-16 in. diam.=13.59 ohms at 15.5°C. or 59.9°F.

HP	Per Ct Effic'y	Watts	Equivalent No 16 c.p. 66 watt lamp	Volts at Brushes. 50	75	110	220	400	500	600	800	1000	1200
				Amperes per Motor.									
½	75	497	7.2	9.9	6.6	4.5	2.2	1.2	1.0				
1	75	995	15.0	19.8	13.2	9.0	4.4	2.4	2.0	1.6	1.2		
1½	78	1435	21.7	28.7	19.1	13.0	6.5	3.5	2.8	2.3	1.7	1.4	1.1
2	78	1913	28.9	38.2	25.5	17.4	8.8	4.8	3.8	3.2	2.4	1.9	1.6
3	80	2797	42.2	55.9	37.2	25.4	12.7	7.0	5.6	4.6	3.5	2.8	2.3
5	82	4549	68.9	90.9	60.6	41.3	20.6	11.4	9.1	7.6	5.9	4.5	3.8
7½	85	6582	100.0	131.6	87.7	59.6	29.8	16.4	13.1	10.9	8.2	6.5	5.5
10	88	8477	128.4	169.5	113.6	77.0	38.5	21.2	16.9	14.1	10.1	8.5	7.0
15	88	11580	175.4		154.4	105.3	52.6	28.9	23.2	19.3	14.5	11.6	9.6
20	90	16578	251.2			150.7	75.3	41.4	33.1	27.6	20.7	16.6	14.0
25	90	20722	313.2				94.1	51.8	41.6	34.5	25.9	20.7	17.2
30	90	24866	376.7				113.0	62.1	49.7	41.4	31.0	24.8	20.7
40	90	33155	502.4				150.0	82.8	66.3	55.2	41.4	33.1	27.6
50	90	41444	626.4				188.4	103.6	82.8	69.1	51.8	41.4	34.5
60	90	49733	753.4					124.3	99.4	82.8	62.1	49.7	41.4
75	90	60815	921.4						121.6	101.4	76.0	60.8	50.7
90	90	72978	1105.7						146.0	121.6	91.2	73.0	60.8
100	92	81087	1128.3						162.1	135.1	101.3	87.0	67.5
120	92	97413	1476.0							162.3	121.8	97.4	81.1
150	92	121630	1842.8								152.0	121.6	101.3
200	92	162178	2256.6									162.1	135.1

Table showing efficiencies of different sizes of motors with correspondent voltage and ampage.

Amp. load of Motor.	Size of Wire. (B & S. Gauge)														
	16	14	12	10	8	6	5	4	3	2	1	0	00	000	0000
	Distance (in feet) of motor from mains that current can be carried with 1 volt loss.														
1	121	192	308	490	778	1232	1560	1920							
2	60	96	154	245	389	616	780	960	1216						
3	40	64	105	166	265	473	531	670	846	1066					
4	30	48	77	122	194	308	390	480	608	780	985	1232			
5	25	39	63	100	160	254	319	402	508	640	806	1020	1282		
7½		25	40	65	104	164	208	258	328	416	525	657	836	1187	
10			31	50	80	126	154	201	254	320	403	510	418	641	
12½				40	61	100	125	153	194	250	315	394	500	712	
15				33	53	84	106	134	169	213	268	340	427	542	
18					43	68	86	106	135	173	219	273	348	495	524
20					39	63	76	100	125	160	201	255	320	406	510
25					30	50	62	76	97	125	157	197	250	356	399
30						47	53	67	84	106	134	164	209	310	340
40							38	50	63	80	100	128	160	203	255
50								40	51	64	81	102	128	162	204
60									42	53	67	82	105	155	170
70										46	58	73	92	116	146
80											50	64	80	102	128
90												56	68	75	107
100													64	81	102
120													54	68	85
150														54	68
200														41	51

Table of sizes of wires for different current capacities of motors, and distances from supply.

ELECTRICAL UNITS.

AMPERE.—The unit of current strength. It is the flow of electricity produced by the pressure of one volt on a resistance of one ohm.

COULOMB.—The unit of electric quantity. It is the amount of electricity which flows past a given point in one second on a circuit conveying one ampere.

FARAD.—The unity of capacity. A condenser that will hold one coulomb at a pressure of one volt has a capacity of one farad.

OHM.—The unit of electrical resistance. Ohms law states that the current in any circuit is equal to the E. M. F. acting on it divided by its resistance.

VOLT.—The unit of electro-motive force or pressure analogous to the head of water in hydraulics.

WATT.—The unit of work. $\frac{1}{746}$ of a horse power, *i.e.* 746 Watts equal 1 horse power. We may find the Watts used in a circuit by three formulae, thus:

Watts = Amperes (squared) × ohms.

Watts = Amperes × volts.

Watts = Volts (squared) ÷ by ohms.

MILLI-AMPERE.—~~One millionth~~ One thousandth ampere and is used as the unit of current when the amount is very small. Its use avoids fractions.

KILO-WATT is the unit for dynamo and even transforms capacity. It means 1000 watts and hence large capacities can thus be expressed by use of but few figures.

RULES AND REGULATIONS

Of the New England Insurance Exchange and Boston Fire Underwriters' Union for electric lighting. [*Adopted April 15th, 1889, and superceding all previous rules.*]

ARC SYSTEM.

OUTSIDE WIRES.

1. All outside overhead wires must be covered with some material of high insulating power, not easily abraded; they must be firmly secured to properly insulated and substantially built supports. All tie wires must have an insulation equal to that of the conducting wires.

2. All joints must be so made that a perfectly secure and unvarying connection, fully equal to the cross-section of the conducting wire will be secured — and they should be soldered. Resin should not used as a flux. Nothing but an acid solution should be used, and any excess should be washed off before the splice is covered. This also applies to inside wires All joints must be securely wrapped with an approved tape.

The following formula for soldering fluid is recommended, viz: —

Saturated solution of zinc..........	5 parts
Alcohol..............................	5 parts
Glycerine............................	1 part

3. Care must be taken that conducting wires are not placed in such a position that it would be easy for water,

or any liquid, to form cross connection between them, and they should not approach each other nearer than one foot.

4. The wires must never be allowed in contact with any substance other than air, and their proper insulating supports.

5. Conducting wires carried over or attached to buildings, *must* be at least seven feet above the highest point of flat roofs, and one foot above the ridge of pitch roofs. Lines constructed subsequent to the adoption of these regulations should not be run over and attached to buildings other than those in which the light or power is being, or is to be used, but should be on separate poles, or structures, where they can be easily reached for inspection.

6. When they are in proximity to other conducting wires, or any substance likely to divert any portion of the current, *dead, insulated* guard-irons must be placed so as to prevent any possibility of contact in case of accident to the wires, or their supports. The same precautions must be taken where sharp angles occur in the line wires, and also where any wires (telegraph, telephone, or others) could possibly, owing to their position, come in contact with the electric light wires.

7. Overhead wires from the main circuit or pole in the street to the terminal insulators attached to buildings, and at the point where they enter a building, must not be less than twelve inches apart. They must be rigidly and neatly run, and supported by glass or porcelain insulators, or rubber hooks. The rubber hooks must be of an approved pattern, *i. e.*, with the rubber insulation free from flaws, and projecting over the hook in cup form.

8. Service blocks must be protected by at least two coats of water-proof paint over their entire surface; and when used to support rubber hooks, must have at least one inch of wood between the inner end of the hook and the back of the block.

9. For entering buildings, wires with an extra heavy water-proof insulation must be used from the terminal insulators outside to the inside of a building. They must loop down, so that water may drop off, without entering

the building, and the holes through which they enter should, where possible, slant upward. If an approved glass insulator for bushing the hole is used, the extra heavy water-proof insulation will not be required.

10. Service wires must come in contact with nothing save air, and their insulating supports, except in unavoidable cases, when a wire with an extra heavy insulation suitable for the purpose must be used.

11. The use of porcelain knobs as insulators, except in perfectly dry places, or for the support of specially insulated wire, will not be accepted, unless of some approved shape.

12. None but an approved tubing will be accepted as a durable water-proof insulation.

13. Wires must enter and leave the building through an approved cut-out switch.

14. The cut-out switch must be "double contact," and should effectually close the main circuit, and cut off the interior, when turned "off." It must be so constructed that there shall be no arc between the points when thrown "on" or "off." It should be automatic in its action in either direction, not stopping between points when once started. It should indicate upon inspection whether current be "on" or "off."

15. It must be mounted on a non-conducting base, kept free from moisture, and easy of access to firemen and police.

INSIDE WIRING.

16. Wires must not be concealed; they must be run in plain sight so as to be open to inspection at any time. They should be kept apart at least twelve inches.

17. In perfectly dry places wires may be supported by cleats of wood (filled to prevent the absorption of moisture) or porcelain. Cleats should be so made as to separate the wire at least one-fourth of an inch from the building.

18. In places liable to dampness, wires must be separated at least one and one-half inches, they must be thoroughly and carefully put up, and supported upon por-

celain or glass insulators, or hard rubber hooks. They should also be provided with an approved insulation covering.

19. When wires pass through walls, floors, partitions, etc., in-doors, glass insulators, or an extra covering of hard rubber, should be used. Wires must never be left exposed to disturbance or mechanical injury.

ARC LAMPS.

20. The frames and other exposed parts of arc lamps must be carefully insulated from the circuit.

21. Each lamp must be provided with a proper hand switch, and also with an automatic switch that will shunt the current around the carbons should they fail to feed properly.

22. Stops of some kind must be provided to prevent the carbons from falling out in case their clamps fail to hold them; and these stops must always be in place when the lamp is burning.

23. For inside use, the light must be surrounded by a globe resting in a tight stand, so that no particles of melted copper or heated carbon can escape. When inflammable material is near or under the lamp, the globe must be protected by a wire netting. Unless a very high globe, which closes in as far as possible at the top, is used, it must be provided with some protector or spark arrester, reaching to a safe distance above the light. Broken or cracked globes must be replaced by perfect ones immediately. (By inflammable material is meant such as dry goods, clothing, millinery and the like in stores; flyings or goods in fabric factories; shavings and saw-dust in woodworking shops, or any other substance that can be readily ignited by droppings or flyings from the lamp.)

24. Electrical connection between the conducting wires and lamps must be made through a suitable "hanger-board" and rods on which the lamp is hung.

INCANDESCENT LAMPS ON ARC-LIGHT CIRCUITS.

25. The rules for running wires for arc lamps apply also to incandescent lamps run in series.

26. These must be provided with a proper hand switch, and also with an approved automatic device which will shunt the circuit around the carbon filament should it break. No electro-magnet device will be accepted for this purpose.

27. Any method of distributing current to incandescent lamps on arc-light circuits, other than as above provided for, must receive the approval of this Exchange before being put into use.

DYNAMOS AND MOTORS.

28. They must be located in dry places, not exposed to the flyings of combustible material, and must be insulated upon dry wood, filled to prevent absorption of moisture. They must be kept thoroughly clean and dry. They must be provided with a reliable automatic regulating device, or a competent person must be in attendance near the machine whenever it is in operation. In wiring for motive power, the same precautions should be taken as with a current of the same volume and potential for lighting.

29. The wires leading to motors should be separated at least twelve inches from each other, and must be provided with an approved cut-out switch at the point where they enter the building. The same precautions must be observed in entering the building that are required for lighting circuits.

TESTING.

30. All circuits should be tested at least twice a day with a suitable magneto, or other approved device, in order to discover any escapes to ground that may exist. One test should be made in the morning, and another in ample time before starting, to remove any defect should it be found to exist. The rules for testing should be observed in any separate or isolated plant the same as in central stations.

31. The New England Insurance Exchange reserves the right at any time to add to, change, or modify these rules, and to enforce such modifications, changes, etc., as it shall deem necessary for safety; and it will use all

reasonable efforts to promptly notify all electric light companies of any change.

32. The signing of these rules by an electric light company, or persons controlling electric lights, shall be considered a guaranty on their part that they will have the testing performed on their circuits or lines as above required.

INCANDESCENT SYSTEM.

OUTSIDE WIRES.

1. All outside overhead wires must be covered with some material of high insulating power, not easily abraded, and they must be firmly secured to properly insulated and substantially built supports. All the wires must have an insulation equal to that of the conducting wires.

2 All joints must be so made that a perfectly secure and unvarying connection, fully equal to the cross-section of the conducting wire, will be secured—and they should be soldered. All joints must be securely wrapped with an approved tape.

3. Care must be taken that conducting wires are not placed in such position that it would be easy for water, or any liquid, to form cross-connection between them, and main conductors or feeders should not approach each other nearer than one foot.

4. The wires must never be allowed in contact with any substance other than air, and their proper insulating supports.

5. Conducting wires carried over or attached to buildings, *must* be at least seven feet above the highest point of flat roofs, and one foot above the ridge of pitch roofs. Lines constructed subsequent to the adoption of these regulations should not be run over and attached to buildings other than those in which the light or power is being, or is to be, used, but should be on separate poles, or structures, where they can be easily reached for inspection.

6. When they are in proximity to other conducting wires, or any substance likely to divert any portion of the current, *dead*, *insulated* guard-irons must be placed so as to prevent any possibility of contact in case of accident to the wires or their supports. The same precautions must be taken where sharp angles occur in the line wires, and also where any wires (telegraph, telephone, or others) could possibly, owing to their position, come in contact with the electric light wires.

7. Wires from main circuit to main cut-out inside of buildings, must be separated by a distance of not less than six inches, for currents having an electro-motive force of 250 volts or less, and this distance must be increased for currents of higher potential.

8. They must also be rigidly and neatly run, and must be supported by glass or porcelain insulators, or by rubber hooks. Rubber hooks must be of an approved pattern; *i. e.*, with the rubber insulation free from flaws, and projecting over the hook in cup form.

9. Service blocks must be protected by at least two coats of water-proof paint over their entire surface; and when used to support rubber hooks, must have at least one inch of wood between the inner end of the hook and the back of the block.

10. For entering buildings, wires of extra heavy and durable water-proof insulation, protected by an outside covering not easily abraded, must be used from the terminal insulator outside, to the main cut-out inside of the building. They must loop down, so that water may drip off without entering the building, and the holes through which they enter should, where possible, slant upward. If an approved glass insulator for bushing the holes is used the extra heavy insulation will not be required.

11. Service wires must come in contact with nothing save air, and their insulating supports, except in unavoidable cases, when a wire with an extra heavy insulation, suitable for the purpose, must be used.

12. The use of porcelain knobs as insulators, except in perfectly dry places, or for the support of a specially

insulated wire, will not be accepted, unless of some approved shape.

UNDERGROUND SERVICE.

13. Where underground service conductors, enclosed in a metal tube, enter a building, special care must be taken at the point where the conductors leave the tube, and thence to the main cut-out, to protect them in such a manner that they cannot come in contact with each other, nor with the tube, nor be acted upon by falling moisture, nor disturbed by anything being moved against them, etc.

14. This service must not end in any place where it would be unsafe or undesirable to place a cut-out, but should be continued by means of specially insulated conductors (and a space of ten inches should be maintained between them) to a suitable location.

INSIDE WIRING.

15. Copper wire used for incandescent lighting must be procured for manufacturers whose products have been found, by reliable tests, to be at least 95 per cent conductivity. Samples of wire to be used, or in actual use, must be submitted to this Exchange, for tests of conductivity, at any time when required. Samples of wire must also be submitted for tests of insulation, at any time when required.

For inside work, no wires smaller than No. 16 "B. & S." or No. 10 "B. W. G." will be approved.

16. Permission will not be granted for the use of the lights unless the wire comes fully up to the standard of conductivity, no matter how well the wiring may be done.

17. All parties, firms or corporations proposing to do construction work or wiring, either outside or inside, must fully satisfy this Exchange of their ability to do the work in a safe and acceptable manner.

18. Before using any new form of insulation, the approval of this Exchange for its use under the proposed circumstances must be secured.

19. The use of lead-covered wire, or wire, the covering of which contains paraffine, is prohibited.

20. Mouldings with open grooves laid against the walls or ceilings will not be approved. A wood moulding having a backing of at least one-fourth inch thickness to intervene between the wire and the wall or ceiling of the building, the backing to be protected by at least two coats of water-proof paint, and the moulding of such shape as to protect the wire from moisture, will be approved.

21. When wires are run in new buildings, and are to be concealed from view by walls and ceilings, care must be taken to separate them ten inches or more, whenever it is possible to do so, by running them singly on separate timbers, studding, etc. Cleats are not desirable for concealed work. All concealed wires should be supported on insulators, such as porcelain knobs, or other equally good, non-combustible, insulating substance. Wires should, where it is possible, be kept from contact with any part of the building by means of such insulators, rather than to depend upon the insulation covering. Where complete separation from the building by air space and insulators is not possible, an approved insulation covering, that shall be water-proof and non-combustible, will be required. Wires run in non-combustible and water-proof tubes, made of a suitable insulating material, will be approved.

Care must be taken to keep the wires away from metal pipes and other conductors. Outlet wires should be left in such a way as not to be injured by plasterers. They should not, as a rule, be brought through the same opening with gas-pipes, but must be carefully insulated from them.

22. Approval will not be given to any work where the wires have been "fished" any great distance.

23. Moulding must not be used in wet places.

24. In dye-houses, paper and pulp mills, and other buildings specially liable to moisture, all wires (except when used for pendants) must be separated at least six inches. The wire must be thoroughly and carefully put up and must be supported by glass or porcelain insulators, or by rubber hooks.

25. In crossing any metal pipes, or any other conductor, wires must be separated from the same by an air

space of at least one-half inch, where possible, and so arranged that they cannot come in contact with each other by accident. Wires should go *over* water-pipes where possible.

26. Where wires pass through partitions, floors, etc., glass insulators, or an outer covering of hard rubber, should be used to protect them.

27. Wires must never be left exposed to mechanical injury, or to disturbance of any kind.

28. Metallic staples must never be used; when staples are used, they must be of an approved insulating material.

29. None but an approved tubing will be accepted as a durable water-proof insulation.

30. Wires of the same polarity, but belonging to different circuits, or leading to and from a double-pole switch, must not run in one groove, through the same tube, nor in the same slot in a cleat.

31. Cleats should be made of well seasoned hard wood (filled to prevent the absorption of moisture), porcelain or other approved material, and so made as to separate the wire at least one-fourth inch from the building. When secured by cleats not over four feet apart and tightly stretched in the same horizontal plane, wires having a difference of potential of 120 volts or less, should be separated at least one and one-half inches; when they are confined in moulding, a half-inch space is sufficient. This rule applies only to small mains, taps, etc.; mains carrying currents of large volume should be separated a greater distance.

32. The dividing strip between grooves in moulding must never be reduced below one-half inch in thickness by cutting out to admit joints in wires.

33. Where exposed to acid fumes, vapors of ammonia, etc., wires should be provided with an insulation that will not be injured thereby, and should be put up in the manner described in Rule 24.

34. All splices in wires must be soldered; a soldering-bolt should be used for this purpose, if possible. Care

must be taken not to render the wire brittle by over-heating. Resin should not be used as a flux. Nothing but an acid solution should be used, and any excess should be washed off before the splice is covered.

35. The insulation of any joint must be equal to that of the other parts of the same wire.

SAFETY-CUT-OUTS AND SWITCHES.

36. Every system of conductors must be protected by safety cut-outs that will interrupt the passage through the conductors of a current stronger than they can safely carry. The carrying capacity (in amperes) of a fusible metal must be less than that of the smallest conductor it is designed to protect. Conductors include wire, cord, binding-serews, contact point of switches, sockets, cut-outs, etc.

Any fuse must melt immediately with any excess of the amperes which it is marked to carry.

37. A cut-out must be placed where the underground or overhead service joins the inside wires, and at every point where a change is made in the size of the wire (unless the cut-out in the larger wire is intended to protect the smaller).

38. Cut-outs, switches, and other devices which occasion a break in the circuit, must be so arranged that leakage of electricity from them is impossible, and should be mounted on non-combustible material; must not be put in places liable to become damp; must be protected from rubbish, etc., and should be easy of access.

39. Where it is necessary to use cut-outs and switches in damp places, great care must be taken to protect them from moisture, and to use only such as are provided with bases that will not absorb moisture.

40. When necessary, cut-out devices must be covered with some fire-proof and water-repelling material.

41. All cut-outs must be double-pole.

42. The plug or other device for enclosing or supporting the fusible strip or wire should be incombustible and moisture-proof, and so constructed that an arc cannot be

maintained across its terminals by the fusing of its metals.

43. No lead or composition strips carrying more than ten amperes before melting, shall be used, unless provided with contact surfaces of some harder metal having perfect electrical connection with the fusible part of the strip.

44. All switches must have a firm and secured contact that will make and break readily, and that will not stick between "full on" and "off," nor get out of repair easily in other ways. The points of contact must not be allowed to scrape or rub the entire surface of an insulating material between the contact strips — an air space must intervene. The carrying capacity of the different parts must be sufficient to prevent heating.

45. Where points varying widely in potential are brought near each other by means of cut-outs, or switches, hard rubber, lava, or other approved material must be used in the construction of the cut-outs and switches.

46. Switches *should* be double-pole, and they *must* be when the circuits which they operate are connected to fixtures attached to gas-pipes.

47. On any combination fixture, no group of lamps requiring a current of seven amperes or over shall be ultimately dependent on one cut-out.

FIXTURE WORK.

48. In all cases where wires are concealed within, or attached to fixtures the latter must be insulated from the gas-pipe by some device approved by this Exchange. An exception to this rule will sometimes be made in the case of a wall gas-bracket wired for one or two lights.

49. When holes are drilled in fixtures, all burs or fins must be removed from the edge of the holes before the conductors are drawn through.

50. When wired outside, the conductors used must be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixture.

51. All wire used for fixture work must have an insulation that is durable, and not easily abraded; and must not

in any case be smaller than No. 18 "B. & S." or No. 20 "B. W. G."

52. Each fixture must be tested for possible "contact" between wire and fixture, and for "short-circuit," before current is turned on.

53. The tendency to condensation within the pipes or fixtures should be guarded against by sealing the upper end.

54. No combination fixture with less than 1-4 inch clear space between the inside pipe and the outside casing will be approved.

PENDANTS AND SOCKETS.

55. No portion of the lamp-socket exposed to contact with outside objects will be allowed to come into electrical connection with either of the conducting wires.

56. Cord pendants must be protected by hard rubber bushing, or something equally good, where they enter the socket.

57. The use of paraffined insulation for pendants will not be approved.

58. Key sockets must not be used with wire pendants, unless the wire be composed of strands, *i. e.*, flexible.

59. When exposed to the weather, or used in wet rooms, care must be taken to keep moisture from the inside of sockets.

60. The weight of every socket and lamp suspended by a cord must be borne by a ceiling block, rosette, or cleat, and by a knot under the bushing in the socket, in order to take all strain from the joints and binding-screws.

61. Flexible cord must not be used except for pendants, wiring of fixtures, portable lamps, and "mill work."

62. The two conductors of flexible cord must *not* have an insulation composed of an inflammable water-proof compound between them, but should be separated by a fibre insulation, or the like. If a water-proof insulation is necessary, it must be placed outside the two conductors, and must in all cases be covered with a non-inflammable outside coating, to prevent cord from carrying fire.

DYNAMOS AND MOTORS.

63. They must be located in dry places, not exposed to flyings of combustible material, and must be insulated upon dry wood, filled to prevent absorption of moisture. They must be kept thoroughly clean and dry. They must be self-regulating, or a competent person must be in attendance near the machine whenever it is in operation. In wiring for motive-power, the same precautions should be taken as with a current of the same volume and potential for lighting. The motor (and resistance box) should be protected by a cut-out, and controlled by a switch.

SECONDARY GENERATORS OR CONVERTERS.

64. Converters must not be placed inside of any building. They may be placed on the outer walls when in plain sight and easy of access, but must be thoroughly insulated from them. If placed on wooden walls, or the woodwork of stone or brick buildings, the insulation must be fireproof. When an underground service is used, the converter may be put in any convenient place that is dry and does not open into the interior of the building; this location must have the approval of the inspector before the current is turned on.

65. The converter should be enclosed in a metallic or non-combustible case.

66. If for any reason it becomes necessary that the primary wires leading to and from the converter should enter a building, they must be kept apart a distance of not less than twelve inches, and the same distance from all other conducting bodies. The insulation of the wire must be of the very best.

67. Safety fuses must be placed at the junction of all feeders and mains, and at the junction of mains and branches where necessary, also in both the primary and secondary wires of the converter, in such a manner as not to be affected by the heating of the coils. Secondary wires, after leaving the converter, will be subject to rules already given for services, inside wiring, etc.

68. Any provision for grounding the secondary circuit

by means of "film cut-out" or other approved automatic device, will be approved. A permanent ground will not be approved.

MISCELLANEOUS.

69. Companies or individuals furnishing electricity from central stations must enter into an agreement with this Exchange, binding themselves to maintain at all times in their stations some approved device to indicate any escape to earth, which may tend to develop leakage to water or gas pipes, or other earth connections within buildings. This approved means of testing shall also apply to separate or isolated plants, where special conditions of moistnre exist, or in buildings snbject to mechanical changes of piping, etc.

70. The signing of these Rules and Requirements shall constitute and be considered an agreement on the part of the signer, that such approved device or tell-tale shall at all times be employed on their circuits.

71. The wiring in any building must test free from "grounds" before the current is turned on. This test may be made with a magneto that will ring through a resistance of 10,000 ohms, where currents of less than 200 volts potential are used.

72. All incandescent work should be inspected before being concealed, and notice should be given this Exchange as soon as work is commenced.

73. The New England Insurance Exchange reserves the right at any time to add to, change, or modify these Rules, and to enforce such modifications, changes, etc., as it shall deem necessary for safety; and it will use all reasonable efforts to promptly notify all Electric Light Companies of any change.

74. Any additional loading of wires, either in a building as a whole, or in any department thereof, without the previous approval of the Exchange, or the Inspector, shall be deemed a sufficient cause for the suspension of permits until such approval is secured. (*See Form F, Inspector's Certificate.*)

NOTES.

A certificate for all new work or changes in old work (Form C. for Arc, Form F. for incandescent) should be signed by the party installing or controlling any apparatus. The certificate should be filed with the Secretary of the Local Board of Fire Underwriters having jurisdiction, if there be such, otherwise with the Secretary of the New England Insurance Exchange, Boston.

This certificate is relied upon as a guarantee until the work can be inspected. Permits for the use of the light or power, may be granted as soon as the certificate is duly filed.

Concealed work should be inspected before being covered up, and as a rule, incandescent work generally should be inspected before current is turned on.

The above Rules and Requirements are jointly adopted by the New England Insurance Exchange, "Associated Factory Mutuals," and Boston Fire Underwriters' Union, and are applicable to all Electric Lighting and Power work in New England, exclusive of buildings in the State of New Hampshire not insured by the "Associated Factory Mutuals."

[Also adopted by the New York State Board.]

NEW YORK BOARD OF FIRE UNDERWRITERS.

Amended Standard for Electric Equipments, Adopted February 27, 1889.

CONDUCTORS.

CAPACITY OF WIRES.

1. The conducting wires must be of copper and must have a weight per running foot at least equal to that of the wire (or parallel group of wires) constituting the main circuit of the magnetic regulator of the electric lamps (arc lamps), or of the armature of the machine employed, whichever of these is greatest.

JOINTS OR SPLICES.

2. All joints on wires must be so made as to secure perfect and durable contacts, which shall always maintain a degree of conductivity at the joint, at least equal to that of the wire generally.

3. The joint must be so made as in the ordinary "telegraph splice" that it is mechanically secure against motion or displacement and must then be further electrically connected by solder so applied as to leave no corrosive or otherwise injurious substance on the connection. After joining and soldering, the joint must be covered with insulating material in such a way as to make the insulation of the joint as good as that of the rest of the line.

4. A joint made by the process of electric welding would be the equivalent of one made as indicated above, but no joint depending on solder for its mechanical integrity either wholly or in part will be allowed.

WIRES EXTERIOR TO BUILDINGS.

5. Outside wires must be covered with at least two coatings, one of insulating material impervious to water, next to the wire, and the other of some substance fitted to resist abrasion or like mechanical injury, and must be firmly secured to substantial approved insulators, adequately supported. All "tye wires" or those used to secure the conductors to the "insulators" must be themselves covered with waterproof insulating and mechanically resistant material similar to that used on the conductors themselves.

6. Overhead conducting wires must be supported on poles as far as possible, so that they can be easily reached for inspection, and when this cannot be done, and special permit is granted allowing them to be carried over attached to buildings, they must be supported at least seven feet above the general level of the roof and at least one foot above the ridge of "pitch roofs."

7. Where wires approach buildings to enter them they should be so located as not to be readily reached by the occupants of such buildings, and in the case of arc light systems must maintain a minimum distance of ten inches and for incandescent systems of six inches except where the wires are carried in conduits.

8. When these exterior electric light wires are near other conductors of any kind capable of carrying off a part of the current if contact should be made, dead insulated guard-irons must be placed so as to prevent such contact in case of accident affecting the wires or their supports.

9. Like precautions must be taken where acute angles occur in the line wires.

10. Overhead wires from the main circuit or pole lines in the street to the insulators attached to the buildings which they enter, must not be less than ten inches apart for arc wires or six inches for incandescent wires carrying currents of 250 volts E. M. F. as a maximum. They must be securely and rigidly supported on "insulators" of glass, porcelain or other approved material.

WIRES ENTERING BUILDINGS.

11. Whenever electric light wires enter buildings through their exterior walls the wires must be firmly supported and incased in tubes of non-conducting material not liable to absorb moisture (*e. g.* porcelain or glass) and so placed as to prevent the entrance of rain water along the wires (*e. g.* the tubes must slope *upward* as they pass *inward* through the wall).

12. Both the ingoing and return wires should enter the building at the same location and pass through an approved manuel "cut-out-box" or switch, which must be placed where it will be easy of access to firemen and the police.

HIGH POTENTIAL WIRES WITHIN BUILDINGS.

13. In the interior of buildings wires for arc lights besides being covered with an insulating covering such as has already been described must be in all cases securely attached and supported by insulators which shall keep them out of contact with any wall, partition, ceiling or floor, so as to secure an air space of at least one-quarter inch between the wire and any adjacent wall, partition or floor, and whenever the wires cross or come near to any other wires, pipes or other conductors, the wires must all be rigidly secured and separated from each other or any other conductors by means of some rigid non-conducting material.

14. Arc wires of opposite polarities (*i. e.*, the incoming and outgoing wires from each lamp or of each circuit) must be kept at a distance not less than eight inches from each other except within the structure of lamps or on switch boards, cut-out boxes or the like where a nearer approach is necessary.

15. In exceptional cases, however, where the wires are so rigidiy secured and insulated that contact or connection between them is quite impossible they may be allowed to approach nearer. (*e. g.* If each wire or conductor is covered with a thick and undisplacable insulation which in turn is covered by a leaden sheath or pipe, and then two or more such pipes are inclosed in an iron pipe in such manner that injury to the lead covered cables is impossi-

ble, this would be an allowable substitute for the eight inches of absolute separation called for in the general rule.)

16. Whenever wires are carried through walls, partitions or floors within a building, they must be surrounded by a special rigid insulating tube or casing impervious to water, and must be so attached and supported as to be secure from abrasion or other mechanical injury.

NOTE.—Rubber tubing will not meet the above requirements as an insulation.

ARC LAMPS.

17. The exterior frames and other exposed parts of arc lamps must be securely insulated from the electric circuit, and all such lamps must have glass globes surrounding the light and inclosed below, so as to prevent the fall of ignited particles. Where inflammable materials are placed below such lamps the globe must be surrounded by a wire netting capable of keeping the parts of the globe in place if it is fractured in use.

NOTE.—Broken globes must be replaced as soon as practicable by new ones.

18. In show windows and other places where inflammable materials are displayed, and in factories or wood-working establishments where "flyings" may be present in the air, each lamp must be provided with "spark arresters."

19. Each lamp must be provided with a hand-switch and also with an automatic switch which shall shunt the current round the carbons before the arc between them reaches a dangerous length.

LOW POTENTIAL SYSTEMS.

DIRECT SYSTEMS.

20. In direct incandescent systems, the rules as to the capacity, location and arrangement of conductors is substantially the same as has been already stated, with the following exceptions:

21. In case the difference of potential at the positive and negative posts of the dynamo or dynamos developing the current is not more than 250 volts the positive and negative wires in aerial lines and elsewhere which would otherwise be required to maintain a minimum distance of ten inches, may be brought to within six inches of each other. Also underground conductors may be enclosed both in the same tube, and if rigidly and securely supported, and surrounded by and imbedded in a solid insulating substance, may lie within one-quarter inch of each other.

22. When underground service conductors enter a building care must be taken that they are at once separated to the required distance (see below) and are adequately and permanently insulated from each other and from the pipe in which they were inclosed, if they were inclosed in a metallic pipe or conduit.

23. They must also be adequately protected from mechanical injury and must be so located that a cut-out can be safely and conveniently located close to the end of the service pipe or conduit by which they are brought in.

LOW POTENTIAL WIRES WITHIN BUILDINGS.

24. In the distribution of the conductors through buildings "concealed work," such as the placing of wires under floors or within partitions, walls or ceilings should be avoided as much as possible.

25. In perfectly and securely dry localities an improved insulated wire without waterproof covering may be used, provided the wires are not concealed and are supported by cleats or insulators.

26. Wherever the wires are to be in any way covered up they must be coated with an approved waterproof insulation.

27. In all cases of concealed work, the company proposing to introduce the same, will be required to furnish the Board with a detailed diagram of the work, showing the kind and size of wire used at the different branches, with particulars as to the insulation and in what materials embedded; location of cut-outs, switches, etc. The dia-

gram to be signed and sworn to by an officer of the company and filed with the Board for reference.

28. If wires are embedded in the plaster or walls, ceiling or partitions, they must be separated not less than ten inches from each other, in addition to being insulated as above described.

29. In buildings in course of construction, terminal wires must be so arranged as to be secure from injury by the plasterers.

30. Wires insulated as above may be covered by or embedded in mouldings in dry locations, but in breweries, paper mills, dry houses, and other like places where they are exposed to moisture, they must be carried out of contact with the walls, ceilings and the like on approved "insulators."

SECONDARY SYSTEMS.

31. In these systems where alternating currents of high electro-motive force are used on the main lines, and secondary currents of low electro-motive force are developed in local "converters" or "transformers," it is important that the entire primary circuit and the transformers should be excluded from any insured building, and be confined to the aerial line (the transformers being attached to the poles or the exterior of the buildings) or to underground conduits if such are used, or placed in fire-proof vaults or exterior buildings.

32. In those cases, however, where it may not be possible to exclude the transformers and entire primary from the building, the following precautions must be strictly observed:

33. The transformer must be constructed with or inclosed in a fireproof or incombustible case, and located at a point as near as possible to that at which the primary wires enter the building. Between these points the conductors must be heavily insulated with a coating of approved waterproof material, and, in addition, must be so covered-in and protected, that mechanical injury to them, or contact with them, shall be practically impossible.

34. These primary conductors, if within a building,

must also be furnished with a double-pole switch, or separate switches on the ingoing and return wires and also with automatic double pole cut-out where they enter the building or where they leave the main line, on the pole or in the conduit. The switches above referred to should, if possible, be inclosed in secure and fireproof boxes outside the building.

35. In the case of isolated plants using the secondary system, the transformers must be placed as near to the dynamos as possible, and all primary wires must be protected in the same manner as is indicated in the second paragraph above.

INSULATION.

36. Where there is a possible exposure to water, the first or second coating must be impervious to the fluid.

37. For incandescent lamp fixtures and electroliers, exceptions may be made to the foregoing rule in which the wires can be placed nearer than the prescribed distance to each other, or to other conductors, provided the fixture is fully insulated at the base from house and ground piping, and further provided that a double pole safety catch is placed at the base of each fixture, or at the nearest branch connection as may be required by the Inspector of the Board.

38. In all cases when combination (gas and electric) fixtures are used, extra precaution must be used to secure complete and continuous insulation from the gas piping.

INSULATION IN GENERAL.

39. It is to be understood as a general or universal rule that all machines, lamps, wires and other parts of electric systems, are to be so constructed, mounted and secured as to insure complete and continuous insulation; with such exceptions only as are hereinbefore stated, and that in no case shall ground circuits be employed or any part of the system be allowed to come in contact with the earth through gas or water pipes or the like.

AUTOMATIC SHUNT.

40. Wherever a current of such high electro-motive force is employed that if concentrated on one lamp or motor of the series, it would produce an arc capable of destroying or fusing parts of such lamp, an automatic switch must be introduced in each lamp or motor by which it will be thrown out of circuit before the arc approaches any such dangerous extent.

41. Means by which those in charge of the dynamo electric machines will be warned of any excessive flow of current, or means whereby the same will be automatically checked, must in all cases be provided.

FUSIBLE OR OTHER AUTOMATIC CUT-OUTS FOR LOW POTENTIAL CIRCUITS.

42. Wherever a connection is made between a larger and smaller conductor at the entrance to or within a building, some approved automatic device must be introduced into the circuit of the smaller conductor at or close to its junction, by which it shall be interrupted whenever the current passing is in excess of its safe carrying capacity.

43. The safe carrying capacity of a wire is the current which it will convey without becoming painfully warm when grasped for a minute in the closed hand.

CUT-OUT BOXES OR SWITCHES.

44. All cut-out boxes or switches, which shift, transmit, or break a current, must be mounted on incombustible bases, and so arranged as to close one circuit before they open another, and operate in such a manner that no arc can be formed between the contact surfaces when thrown "on" or "off." It must be so far positive in its action that it cannot stop between its extreme positions. It must indicate on inspection whether current is "on" or "off." This rule applies to isolated plants as well as to those connected with central stations.

MOTORS.

45. The Rules and Regulations under the head of *capacity of wires*, insulation, automatic cut-outs and switches

shall be observed, where electric motors are used, and in addition the motor frames must be properly insulated, and so mounted as to be free from grounds, and each motor shall be provided with an approved switch to prevent an excessive flow of current.

STORAGE BATTERIES.

46. When the current for lights or power is taken from storage batteries, the same general regulations are to be observed.

MEANING OF TECHNICAL TERMS, ETC.

47. High Potential Circuits or Wires. This term includes all wires arranged with the view of carrying currents of more than 250 volts difference of potential between any two parts of the system, even if such current is used to run incandescent lamps.

48. Low potential currents or wires are such as do not carry currents of more than 250 volts.

49. Companies furnishing electricity from central stations must enter into an agreement with the New York Board of Fire Underwriters, binding themselves to test their lines for ground connections at least *once* every day (and preferably three times per day), and to report the result of such tests to the Board weekly.

50. The rules and regulations of the Board of Electrical Control and all existing regulations of the local authorities in reference to stringing of wires must be strictly observed.

RULES

OF THE

New York Board of Electrical Control

AS TO

OVERHEAD CONDUCTORS IN NEW YORK CITY.

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1. No two lines of poles bearing conductors of a like class shall be erected on any street or avenue.

2. No two lines of poles shall be erected on the same side of any street or avenue.

3. Poles shall be set in the sidewalk twelve inches from the outside of the curb, and no pole shall be placed within ten feet of any lamp-post or other pole, except at street corners where necessary in order to support wires running on the cross street.

4. All poles now standing, or to be hereafter erected, shall be branded or stamped with the initials of the company owning them, at a point not less than five nor more than seven feet from the street surface; and when a pole is occupied by wires belonging to more than one company, each group of cross-arms, or where necessary the support of a single wire of different ownership, must be distinguished by some characteristic paint, mark or fastening.

5. Electric light lamp posts shall be in accordance with the plan adopted by the Board.

6. All poles erected for the purpose of carrying lines of more than two electric light or power wires shall be at least forty-five feet high, uniform in size, straight and

painted from top to bottom—a very dark color from the sidewalk to a point eight feet high, and a dark green color above that.

7. All poles for carrying not more than two electric light wires shall be twenty-five feet high, straight, uniform in size, and painted from top to bottom—a very dark color from the sidewalk to a point eight feet high, and a dark green color above that.

8. Cross-arms shall be uniform in length, strengthened by braces, and painted the same color as the poles; the cross-arms of each company being distinguished by some characteristic mark.

9. Each line of poles must be run on one side of the street only, except when absolutely necessary to change to the other side; but this may only be done by the permission of the Board or of its engineer or expert.

10. Electric light conductors must not be placed upon fixtures erected or maintained for supporting wires of the other class, namely those for signaling, except by permission of the board.

11. Poles shall be uniformly spaced, and about sixty to the mile. This requires on the short city blocks of two hundred and sixty feet, alternately three and two poles to the block.

12. All conductors shall be secured to insulating fastenings, and covered with an insulation which is water-proof on the outside, and not easily worn by abrasion. Whenever the insulation becomes impaired it must be renewed immediately.

13. No wire shall be stretched within four inches of any pole, building or other object without being attached to it and insulated therefrom.

14. Every wire must be distinguished by a number plainly marked on each cross-arm under the insulator.

15. No unused loops from electric light circuits shall be allowed to remain after lamps are taken away, except in cases where it is positively known that the lamp will be required again within three months, and where there is no underground conduit for that class of circuits.

16. All arc lamps must be so placed as to leave a space underneath of nine (9) feet clear between lamp and sidewalk.

17. All wires must be stretched tightly and fastened to glass or porcelain insulators, approved by the expert, with a strap of the same kind of wire.

18. All connections with lines of electric light conductors shall be made at right angles to the same; and connections to buildings shall be run straight across to the building and then down the front of the building.

19. All joints must be as well insulated as the conductors, and the insulation of joints shall be maintained.

20. Every line entering a building shall be controlled by a cut-off, placed near the entrance, in sight, and easily accessible.

21. No wires shall hang within twenty-five feet of the pavement at the lowest point of sag between supports.

22. In the construction of lines the insulation to be used must be approved by the expert of the board in writing, and the insulation resistance must be maintained in accordance with a standard to be not less $\frac{1}{80}$ megohm per mile per hundred volts. And under no circumstances shall underwriters' wire be used.

23. All circuits must be tested every hour, and when a ground comes on, effort must be made to remove it at once. Failing in this, the current must be discontinued, until the insulation is restored.

24. The insulation must be preserved throughout the entire circuit, and if any portion of a lamp or fixture is a part of the circuit and can be touched, it must be insulated.

25. All conductors shall have a resistance uniformly distributed of not more than 30 ohms per mile per ampere, and proportionately less for heavier currents.

26. All existing regulations of the local authorities in regard to the placing of poles and stringing of wires are to continue in force, except when in conflict with these rules; and the rules and regulations of the New York Board of Fire Underwriters must be strictly observed.

27. The violation of any of the rules and regulations of the board shall operate *ipso facto* as a revocation of the permit held by the company or person guilty of such violation.

28. Whenever hereafter any company shall be permitted by this Board or its successors to erect posts or poles, or other fixtures bearing lamps or other devices, for the purpose of lighting by electricity the streets, avenues, highways, parks or public places of the city, the said permission shall be granted only subject to the following provisions, and the same is hereby expressly made a condition of said permits. At any time when, by action of the city authorities, the contract for lighting any such street or other public place shall be given to another company, the company erecting said lamp-posts shall, on tender of the first cost thereof, yield possession and ownership of the same to the said other company obtaining the new contract, except in cases where the company owning the lamp-posts prefers to remove them.

29. All broken and "dead" wires, and all wires, poles and fixtures not actually in use—subject to rule 15—must be removed from the streets, avenues and highways of the city. When an old pole is taken down it must be removed from the streets the same day. New poles must not be brought upon any street more than two days in advance of their erection. Any pole that shall lie on any street more than two days shall be removed by the Bureau of Incumbrances of the Department of Public Works, at the expense of the party owning it.

30. On and after the first of January, 1889, no company shall do business of arc electric lighting in the city of New York without a certificate of the Board, granted on the recommendation and after inspection by the expert of the Board, to the effect that its lines comply with all the rules and regulations of the Board, and that its plant is in proper condition for the doing of its business. The force of the certificate to continue until changes are made, of which the Board must be notified and approve, or so long as the plant and conductors remain in the same condition as when inspected.

31. Every lineman must wear a badge in a conspicuous place, giving his number and the name of the company by whom he is employed.

32. All permits of the Board for overhead wires and fixtures are granted only pending the providing of underground accommodations in the neighborhood of the street or avenue for which the permit is granted.

33. Any member or officer of the Board, and every inspector employed by it, as well as every member of the police force of the city, shall be entitled to examine permits under which work of any kind is being done.

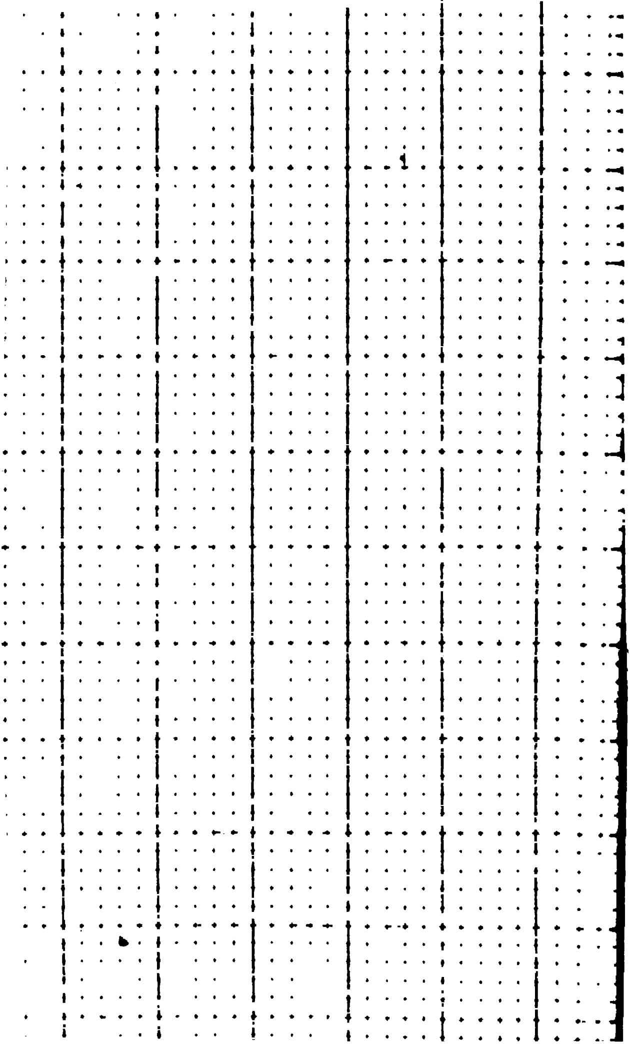
34. No permit shall be granted for the erection of any overhead structure nor for the renewing of any lines already existing in any street, avenue or highway in which underground accommodations for the service have been provided, or are being provided.

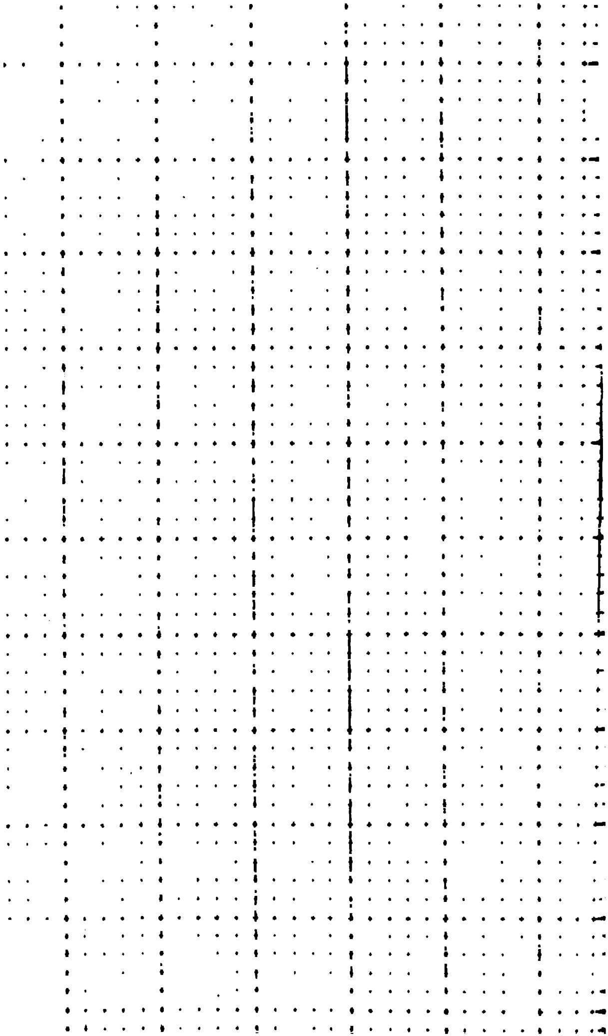
35. Every line, pole, fixture, etc. must be kept in thorough order, repair and conformity with these rules and specifications, upon penalty of forfeiture of all permits granted to the owner by this Board. But the general permit under which these repairs are to be made does not cover the erection in any street, avenue or highway of any new poles of other similar fixtures, and has absolutely no reference whatever to lines which have been ordered underground by the Board, and which the Mayor has been requested to remove. In the case of such lines, where notice has been given that underground accommodations have been provided, and the ninety days of notice required by law have elapsed, and the Mayor has been requested to remove the same, companies owning or operating such lines are not authorized to make any repairs or connections or to go upon the poles bearing such lines *for any purpose whatever*, except to remove the said lines of electrical conductors in conformity with the directions of the Board. Any deviation from this rule requires a resolution passed at the regular meeting of the Board, attested by the secretary.

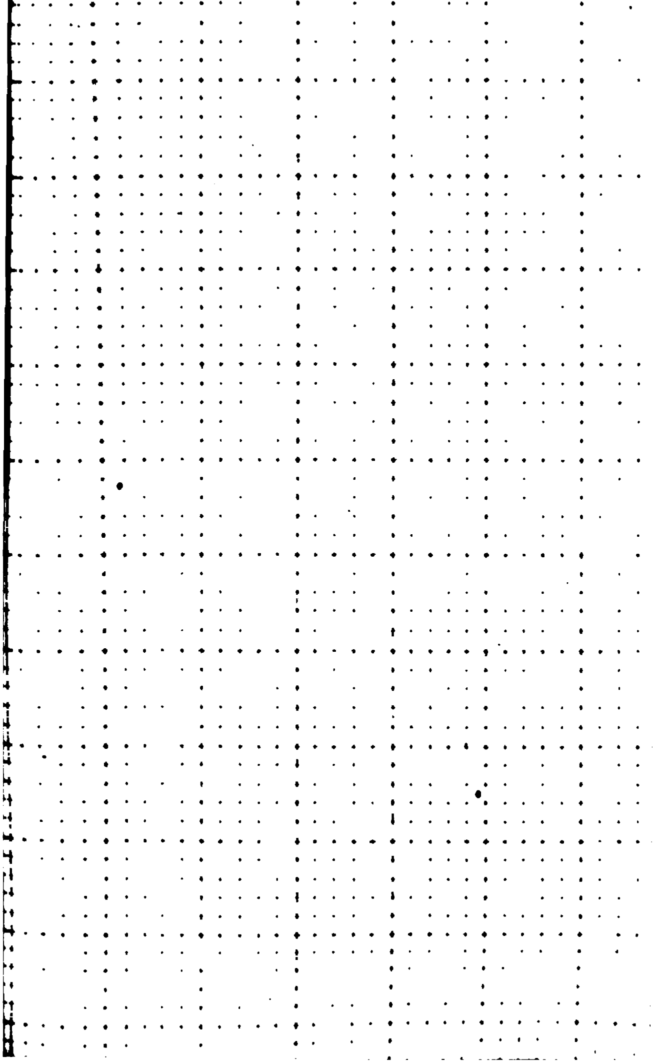
36. Every company or person erecting poles, wires or fixtures must make and leave, at least once each week, at the office of the Board, such records of the fixtures, etc.,

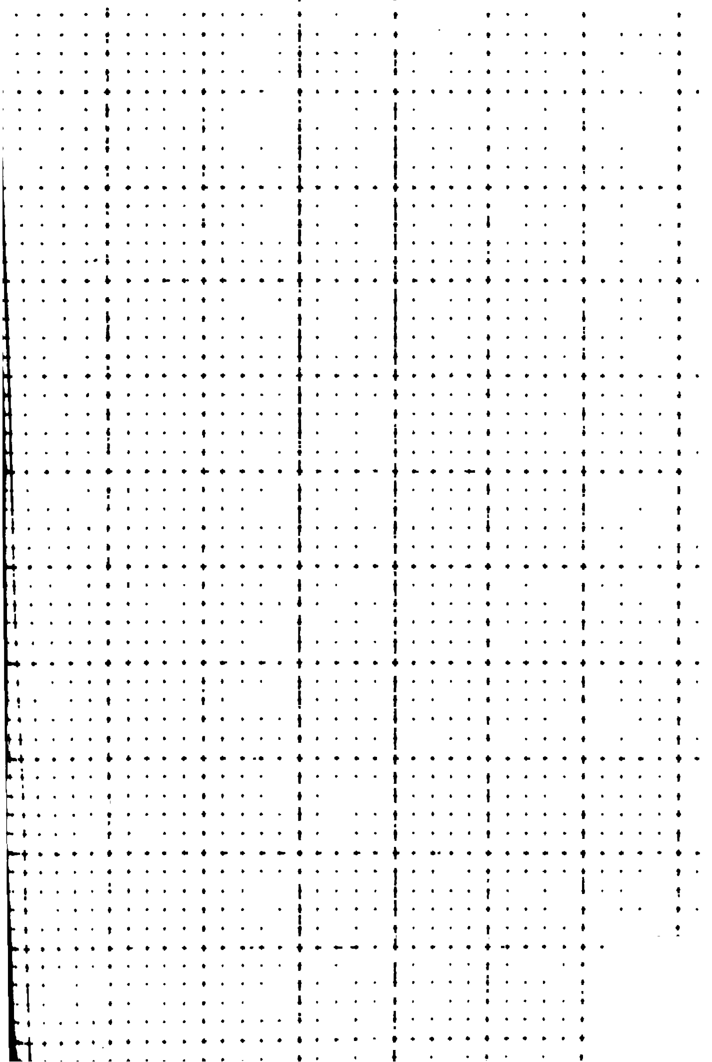
which they are erecting, and of all of the same that they have in use, as are required by the engineer and the electrical expert of the board, and in such form as shall be prescribed by them.

37. The companies or persons owning or controlling poles in any street or avenue, erected under permits of this Board or the Board of Electrical Subways, shall allow the same to be used by other companies or persons operating conductors for similar electrical service when authorized so to do by the Board, on tender of proper compensation, to be determined by agreement between the parties interested. In default of such an agreement the amount of such compensation shall be determined by the board. This rule imports a contract on the part of each company or person owning or controlling the poles on any street or avenue, not only with the board, but also with each company or person who shall under its terms be qualified to demand the privileges it confers, to permit this joint use of poles. And in accepting any permit the applicant thereby binds himself to this agreement.









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